

Ecological Flows Science Advisory Board (EFSAB)

Meeting Summary

February, 19, 2013

Stan Adams Educational Center, Raleigh NC

X DRAFT for review March 4, 2013

APPROVED for distribution

Attendance

Members

Hugh Barwick, Duke Energy
Mark Cantrell, US Fish & Wildlife Services
Bob Christian, East Carolina University
Tom Cuffney, US Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Sam Pearsall, Environmental Defense Fund
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson, NCAWWA-WEA
Jay Sauber, NC Division of Water Quality
Bill Swartley, NC Division of Forest Resources
Fred Tarver, NC Division of Water Resources

Division of Water Resources

Harold Brady
Jucilene Hoffmann
Ian McMillan
Don Rayno
Sarah Young

Alternates

Rebecca Benner, The Natural Conservancy
Peter Caldwell, USDA Forest Service
Bob Christian, NC Division of Marine Fisheries
Sarah McRae, US Fish & Wildlife
Vann Stancil, NC Wildlife Resources Commission

David Williams, NC Soil & Water Conservation Division

Guests:

3 Unidentified Guests
Ed Bruce, Duke Energy
Ed Buchan, City of Raleigh
Dean Carpenter, APNEP
Anne Coan, NC Farm Bureau
Michele Cutrofello Eddy, RTI
Mary Daly, NC Ecosystem Enhancement Program
Mike O'Driscoll, Eastern Carolina University
Joy Fields (online guest)
Rick Gaskins (online guest)
Lisa Perras Gordon (online guest)
Haywood Phistic, LNBA (online guest)
Dan McLawhorn (online guest)
Jim Mead, Environmental Defense Fund
Kimberly Meitzen, The Nature Conservancy
Narayan Rajbhandaaie (Raj), NC Division of Water Quality

NCSU Facilitation Team

Mary Lou Addor, Natural Resource Leadership Institute (NRLI)
Christy Perrin, Watershed Education for Communities and Officials (WECO)
Nancy Sharpless (NRLI)

The purpose of the Ecological Flows Science Advisory Board: The Ecological Flows Science Advisory Board (EFSAB) will advise NC Department Environment and Natural Resources (NCDENR) on an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

Presentations, reports, and background information of the EFSAB are available at: www.nc-water.org/sab

Webinar: If you cannot attend the meeting in person but would like to join us via the webinar, you can watch the presentations and listen to the live streaming audio of the meeting by going to <https://denr.ncgovconnect.com/sab/> and typing your name in the space labeled "guest."

NOTE: The EFSAB will meet **March 19, 2013, 9:00am until 4:15pm** at the Stan Adams Training Facility Jordan Lake Educational State Forest Center Chapel Hill, NC
(see last two pages for meeting agenda topics and directions to location).

Feb 19, 2013: Summary of Decisions/Recommendations and Proposed Actions

Decisions and Recommendations

1. Members of the EFSAB were in support of moving forward without the 3-Way Comparison of Oasis, WaterFALL, and USGS data given the issues the small study team examined initiating the study.
2. All members are asked to review the EFSAB Assessment distributed at the Feb 19, 2013 meeting in preparation for the March 19, 2013 meeting. If there are corrections or clarifications that an individual member would like to add, he or she was asked to email or call Mary Lou Addor with those corrections or clarifications before the meeting.
3. All members are asked to consider the EFSAB report template between now and the March workshop, and consider the outline and sections he or she might contribute to writing.
4. Confidence level of support for WaterFALL: most EFSAB members had a fairly high level of comfort with WaterFALL being used as a tool moving forward, with 2 indicating that they could live with it, and 1 indicating they did not have strong confidence in supporting WaterFALL but would not block others members from supporting its use. [The level of confidence does not preclude the use of other models and there is major concern from a member whether DWR will be able to purchase use of the model in the future].

Proposed Actions

1. Schedule BEC Presentation for Sept 2013 Meeting (possibly a two-day meeting)
2. Look into scheduling a presentation of the SALCC Classification for April 2013

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I. Executive Summary

TITLE: BRIEF UPDATE ON THE BIOLOGICAL-ENVIRONMENTAL CLASSIFICATION (BEC) SYSTEM STUDY & INVERTEBRATE ECOLOGICAL FLOWS STUDY

Sam Pearsall provided an update on behalf of Jennifer Phelan (RTI) regarding the Biological-Environmental Classification (BEC) system study, including preliminary indicators of how the study may inform the EFSAB's work and the anticipated timeline. Data sets are being assembled and thus progress is being made. The first draft is expected to be completed by the end of August 2013; the EFSAB is expected to hear about the BEC at the September 24 meeting. Thomas Cuffney reported that the US Geological Survey and NC Division of Water Resources (DWR) have entered into a cooperative agreement to fund a study of the NC Division of Water Quality (DWQ) invertebrate data.

Questions (Q), Comments (C), Response (R):

C: Thank you to the agencies and organizations that are working diligently to provide additional data to help develop an approach to characterize the aquatic ecology of different river basins.

Proposed Actions or Identified Decisions to be made: Schedule BEC Presentation for Sept Meeting (possibly a two-day meeting)

TITLE: BRIEF STATUS REPORT ON 3-WAY COMPARISON FOR OASIS, WATERFALL AND USGS DATA

(Presenter: Sam Pearsall, Environmental Defense Fund). During the Nov 27, 2012 meeting, the EFSAB supported the idea of Brian McCrodden, Sam Pearsall, Michelle Eddy, and Thomas Cuffney moving forward with a 3-Way Comparison of Oasis, WaterFALL, and USGS data. The small study ran into several issues. As a result, a 3-way comparison may not matter since the EFSAB is trying to develop a strategy. Later if there are better models and inputs system, the assumption is that the strategy will work but only better.

Questions (Q), Comments (C), Response (R): None

Proposed Actions or Identified Decisions to be made:

Members of the EFSAB were in support of moving forward without the 3-Way Comparison of Oasis, WaterFALL, and USGS data given the issues the small study team encountered.

TITLE: REVIEW OF FINDINGS OF WATERFALL ECOFLOW METRICS AS COMPARED TO THE GAGE METRICS

Presenter: Michele Eddy, RTI

Michele Eddy presented two brief summaries:

- 1) the results of a model-comparison workshop, in which WaterFALL was compared with 6 other models. Results show WaterFALL has similar performance to other models (9 applications in total) in terms of model efficiency and bias in monthly and annual metrics.
- 2) An Ecoflow metric comparison between WaterFALL and USGS gages. In summary:
 - Largest variation is not by percentile but by month
 - Most variation in fall (measured by relative percent difference, RPD): *September, October, and November*

- Always a couple outliers in each percentile in each month
- Some tendency to overestimate Median to Extreme High flows in September through November yet.....
- Across the 51 sites the median RPD between the gage and model is <25% for all months and all percentiles except for Median to Extreme High flows in October (still <30%) and Extreme Low to Median flows in November (still <30%)

Questions (Q), Comments (C), Response (R):

Q: That green triangle [One site (green triangle on graphs) showed as a significant outlier.] when you pointed out that that was Rocky River, Norwood, it's not that surprising because this simulation used a 1970 land cover, is that correct?

C: When you think about the Rocky River watershed, you've got Charlotte in the upper end, Concord, Kannapolis, and all that west—east of Charlotte land cover change that's been happening since '70, '80 whenever—which the gage is reflecting, which wasn't there in the early part of the gages. We're getting just a bit slow there accumulating through the record, whereas your simulation basically catches all that land change. Instead it had been there for the entire 30 years. That kind of situation it is not surprising to see some issues.

C: It looks like in general it underestimates for the perennials.

Q: When you did your simulations, you didn't do them separately by month but it was through the whole time, so if you had a high—had a storm at the end of September, you should see a correspondence to the gage in October, right? In other words, you should see the state in both conditions. R: We try to match those peaks but there are times when the timing just got off a little bit.

Proposed Actions or Identified Decisions to be made:

1. To get consensus that we don't necessarily need any additional presentation on the quality of WaterFALL, that maybe we are there, that we have confidence, and we can go forward. [The facilitators suggested waiting until after Fred's presentation to consider that.]

TITLE: BENEFITS OF HAVING DWR COMPARE THE HYDROLOGY OF 9 HABITAT SITES USING WATERFALL

Fred Tarver presented the results of selected model comparisons of OASIS and WaterFALL flow records at 9 of DWR's in-stream study sites. This comparison had been proposed as an alternative to running full habitat response comparisons. The two models matched well at some sites, but not so well at others. Fred noted some potentially confounding factors influencing the comparison:

- WaterFALL simulations used the 1970s land use layer. Some catchments still with low-density development? Some sites proximal to reservoirs that may dampen the impact of changing land use?)
- Assumed to have similar drainage areas due to data request based on latitude-longitude coordinates; however have not verified with elevation model.

Fred asked the Board for their thoughts on whether to run PHabsim analyses with WaterFALL to compare those habitat results with OASIS habitat results at a couple of the sites that did not match well.

Questions (Q), Comments (C), Response (R): :

- The EFSAB may already be comfortable enough.
- I don't see the benefit of going through all the gyrations for the PHABSIM until we've worked out why WaterFALL and OASIS are not matching up.
- I hope that we're not going to be limiting the tools that are available to the Division of Water Resources as we begin focusing on the notion of how do we determine the needs for ecological flow.

- They are only models, there is not truth in either one of them. They are reasonably in agreement with each other, similar to the way many other models are reasonably in agreement with each other.
- They are both going to change over time, and the Division of Water Resources, based on site specific permit requests for removal of flow for various reasons, is going to end up using the best tool that they think fits that particular request and site. They will clearly be using both of these as long as they're both on the table.
- if WaterFALL had come first, we'd be wondering is OASIS good enough? But because OASIS was done first, we're wondering if WaterFALL is good enough.
- Buckhorn Creek was one of the worst bits there. In talking with the folks from Hydrologics, they had a heck of a time developing the OASIS model for Buckhorn Creek. Most of its record was influenced by Shearon Harris dam, and they were trying to create an unregulated record for that creek. So they had to try to back out the effects of this massive reservoir upstream of the gage....In the Rocky River, I spoke earlier about how little gaging OASIS had there to base their model on.
- Instead of doing all 9, because it's going to be an arduous process to try to compare habitat as opposed to what you did with just comparing cfs to cfs, pick 2 to 4. I would not pick Buckhorn Creek because of problems with OASIS there. But pick a couple and just put the nail in the coffin.

Proposed Actions or Identified Decisions to be made:

- Does the EFSAB feel comfortable with both WaterFALL and OASIS?
- Should DWR run PHABSim analyses using WaterFALL to compare with OASIS analyses?

TITLE: Update on The Nature Conservancy's Environmental Flows Project for North Carolina

A presentation to update the EFSAB on the TNC Environmental Flow project was provided. This project's goal is to identify stream reaches with the greatest resiliency and conservation potential for supporting healthy biodiverse freshwater ecosystems. The environmental flow study is one part of the TNC's Freshwater Resilience Project. Kimberly Meitzen project consists of the following steps:

1. Conduct literature review to develop flow-ecology relationships for NC riverine biota and physical stream processes
2. Analyze changes in (a.) flow patterns and (b.) biota over recent history of flow impacts
 - 3a. Identify patterns of biotic changes
 - 3b. Identify spatial and temporal patterns of flow changes
4. For TNC, develop flow-ecology criteria and flow recommendations to protect riverine ecosystem integrity characteristic of NC's biotic and physiographic diversity (created a Decision Support System for Environmental Flows -DSSEF)
5. Identify areas of conservation priority relative to freshwater ecosystem resilience and vulnerability

She shared some results and patterns of biologic changes, and spatial and temporal patterns of flow changes (steps 2 & 3 above), for the 4 river basins she focused upon- Roanoke, Tar-Pam, Cape Fear, and Little Tennessee. She shared maps represented biotic changes over time for both fish (141 sites) and benthic macro-invertebrate communities (234 sites) by representing variation in diversity and abundance via coefficient of variations (CV). This is to show which sites changed more during contemporary conditions (meaning from 1982-2010). Benthos communities showed a larger rate of change, meaning they have been more sensitive. In general, the Little Tennessee is more stable, Dan River headwaters of Roanoke has been relatively stable for biota. Some areas of Cape Fear and Tar-Pam show a lot of change for biota.

For the flow analysis she used USGS Stream flow gauges in the 4 basins. She showed % change over time for the

90th, 75th, 50th, 25th, and 10th percentile flows. (90th being high flows, 10th being lowest). For each percentile she showed 1) A graph of all months that shows % change, where >25% change is significant, and 2) A map that shows average % change for all months, with the range indicated. She noted a few things- in Sept, Oct, Nov, 90th percentile flows all increased significantly; a lot of stress seen for 10th percentile flows in Aug, Sept., Oct., July.

Kim provided a 5 step decision-making process that TNC will be looking at to develop their own recommendations for ecological flows. They will share any information or analyses that EFSAB would like to see for their own consideration.

Questions, Comments , Concerns raised:

- The take-home seems like high flows seemed to be higher in recent years, low flows tend lower in recent years, possibly due to greater impervious surface, more people, and agriculture use.
- Yes though *the change is highly variable across state, and variable across month*, why it's important to have specific flow recommendations for each month. Changes also vary across ecoregions, changes may be consistent in smaller basins- some of the smaller basins may need more protective measures.
- We have to be careful to determine cause and effect of change of flows of highs and lows without looking in detail at other variables (dam impacts, land use change, irrigation schedule, evapotranspiration & infiltration rates, and natural and production food growing seasons.

Proposed Actions or Identified Decisions to be made: none.

TITLE: PREFACE TO THE PATH FORWARD

Fred Tarver shared with the group how the EFSAB recommendations would and would not be used. The legislation indicates that recommendations will not impose any additional regulatory requirements, meaning the process is about planning, not policy.

He showed a flow chart of how the EFSAB may develop eflows, regarding potential classification or not, and physiographic overlays that go into developing e-flows using the habitat scenario modeling. (see his fabulous slide below). He explained the various audiences for the EFSAB's recommendations, and how the e-flows and models will benefit water users by providing some level of certainty regarding availability of the resource over a 20-50 year planning horizon, and allow for significant time to plan ahead. The models can also be used for "what if" scenarios.

Questions, Comments, Concerns raised:

- Are there audiences missing from the presentation who will challenge the science?
- The EFSAB represents the science of the constituent organizations, not necessarily their agendas. They are a science board, not a policy board.
- The definitions in the legislation (essential water use, meeting all needs, etc) are broad.

Proposed Actions or Identified Decisions to be made: none.

TITLE: INTRODUCTION TO THE EFSAB ASSESSMENT

Mary Lou Addor introduced the results from a brief assessment conducted with the EFSAB during January, 2013 was presented. In all, 23 members and alternates of the EFSAB (out of 26 possible) participated in the

assessment via phone interviews including former members. The data gathered resulted in valuable responses that were distilled into a summary. The purpose of the assessment was to help clarify issues before the EFSAB and to determine how to increase the likelihood that the EFSAB can generate recommendations that will advise the NC DWR on how to characterize the natural ecology and identify flow requirements. The assessment was also designed to assist the project team (DWR staff and the facilitators) with recommendations for structuring the 2013 process. **The assessment resulted in 11 major themes (pg. and 10 major concerns (pg)**

Members identified several approaches to help characterize the aquatic ecology of different river basins:

- a. Determine What is Good Enough
- b. Distinguish Level of Detail Required
- c. Characterize the Ecology by what Cuffney has done for macroinvertebrates
- d. Levels of Alteration Approach
- e. Levels of Classification Approach
- f. Basin Level Approach (Scale of Approach)
- g. Characterize by geomorphology
- h. Characterize by Seasonal Approach
- i. Additional Scientific Information Required
- j. Clearly defined biological component/process for describing the ecology
- k. Decision point on Scale and Scope
- l. Firm up a guiding principle of classification of ecology (temperature, flashy/riffle/pool, etc.)

Members identified several approaches to help identify the flow necessary to maintain ecological integrity:

- a) Determine specific items
- b) Decide on specific items such as family of strategies and strategies not to use, plus how to treat coastal area.
- c) Gather additional data
- d) Provide methods, not specific flow numbers, characterize ecology broadly.
- e. Scope of decision making is broad and general (keep recommendations at large scale)
- f. Assumptions behind EFSAB Recommendations
- g. Hone in on Planning Component
- h. Value and include a wide range of scientific opinions

Members provided recommendations for meeting procedures and/or structures that would aid the process of providing recommendations. This section also included general comments, suggestions, or concerns. The major categories that resulted were:

- a. Reactions to Past Two Years
- b. Develop a visible Project Timeline
- c. Establish Process Design to Accomplish 2013 Goals
- d. EFSAB Report: Outline, Process for Compiling Data and Writing, Other Requirements
- e. General Meeting Design
- f. Recommendations for Process
- g. Recommendations to the Project Team (DWR and Facilitators)
- h. Post-EFSAB process concerns and suggestions (2014 and beyond)

Questions (Q), Comments (C), Response (R): Would the assessment help the project team move forward? Yes, it is designed to help the project team AND the EFSAB to move forward once all members have read the report.

Proposed Actions or Identified Decisions to be made:

Each member of the EFSAB was asked to read the meeting summary in its entirety. Members were asked to determine whether their comments were accurately reflected in the summary and to listen to the suggestions

and recommendations being posed by other members in preparation for the March 19, 2013 meeting.

TITLE: REPORT OUTLINE AND APPROACHES FOR COMPLETION

A proposed outline for the EFSAB's report was developed by DWR and presented at the February meeting. DWR believes the audience for the report is composed of:

- a. A wide range of people with different levels of interest.
- b. Anyone picking up the report, whether present at the meetings or not should be able to go through it and get a firm grip on the process.
- c. EFSAB could have a technical guidance document, some kind of condensed version of recommendations, in the back of the appendices.
- d. The report should meet the needs of all the record books and people in our audience, whether it's the ERC, the EMC, the public or utilities, or water systems. It needs to be pretty thorough.

Q: Does the legislation require a report? We are advising. It could be a memo rather than a report? With a big appendix.

C: Change "literature cited" to an annotated bibliography.

C: A variety of perspectives were shared on how to approach "other states efforts". Throughout the outline, it says the environmental flows, instead of ecological flows. That was not intentional.

Approaches to Dividing Up the Report Writing

1. Facilitators' suggestions:
 - a. Do executive summary last
 - b. Division of Water Resources and the facilitators write the introduction, with DWR doing the background and the facilitators doing the process summary.
 - c. Groups from the EFSAB could take on most of the rest except for the appendices.
 - d. the supporting information review is ready to be written, and those EFSAB members with time now as opposed to later could write those sections, whereas those with more time later could write the accomplishments/discussion and recommendations sections.
2. Comments/suggestions:
 - a. TNC could present the literature they have been working on.
 - i. EFSAB needs to use what has been distributed and reviewed by the Board.
 - b. The people who made the presentations should be asked to summarize them or create topical writing teams to cover similar presentations with a summary of the impact on EFSAB Recommendations rather than simply summarizing what's in the meeting summary.
 - c. The facilitators could assess from the meeting summaries who is best suited to write summaries of presentations.
 - d. I think getting writing teams together and getting assignments to sections comes after approving the outline. And those should be items 1 and 2 of the next meeting.

Proposed Actions or Identified Decisions to be Made:

1. Change outline to say ecological flows rather than environmental flows.
2. Does the EFSAB need to write a final report?
3. If so, do they approve the outline?
4. If the EFSAB decides they should a report, who will write what sections of the report?
5. Change "literature cited" to annotated bibliography?

TITLE: SYNOPSIS OF MEETING BY EFSAB MEMBER

Bob Christian stated he was impressed with how much work for the state is being done by NGO's and non-state organizations—and that this effort must be acknowledged. The first part of the day dealt with various aspects of the hydrological modeling, and the good news is that for the biological and environmental classification, it looks like funding is in place for both the fish and the invertebrates and for [completion at] the end of the summer. During the comparison of OASIS/WaterFALL and gauging stations; the results were it works sometimes, but not others. The Resilience Project will result in recommendations for ecological flows for the Nature Conservancy. The EFSAB spent the afternoon conducting a series of exercises to get the group on the same page and moving forward.

II. Feb 19, 2013 Meeting Orientation and Nov 27, 2012 Meeting Summary Approval

Members and alternates of the Ecological Board Science Advisory Board introduced themselves and their affiliations. Guests in attendance and the facilitation team also introduced themselves. Everyone was reminded to sign-in who attended the meeting.

A brief orientation was conducted of the meeting facilities (restrooms, concession) and available technology (webinar). Members and alternates are encouraged to sit at the main meeting table and guests at tables away from the main meeting spaces. During discussions of the members and alternates, guests may comment once members and alternates have completed their comments and questions. During small group work, guests can also participate in small group discussions but may not dominate the time. Everyone is asked to ensure that space is created for others to engage. From time to time, the facilitators will conduct a straw poll to determine the current level of support for an idea or what additional information is needed, not necessarily for a final decision.

The EFSAB approved the November 27, 2012 that was amended with minor edits to presentations by the presenters.

The agenda for the meeting was introduced. The meeting objectives included:

- Receive an Update on the Biological-Environmental Classification (BEC) System & Invertebrate Ecological Flows Study
- Compare Findings of WaterFALL Ecoflow Metrics to Gage Metrics
- Gain Additional Insight into the Potential use of WaterFALL
- Receive an Update on the Nature Conservancy Watershed Approach
- Develop A Path Forward- DWR Perspective
- Assess How the EFSAB Might Move Forward in 2013 – What are Major Themes and Concerns
- Familiarize the EFSAB with an Annotated Meeting Information Tool - What Can Be Improved
- Establish a Shared List of Assumptions
- Determine Issues to Address and When
- EFSAB Report – Develop Format, Seek Approval on Format, Strategize a Plan for Moving Forward, and Agree to Plan

The purpose of the project is for planning not policy recommendations. From 2011 to 2012, the EFSAB focused on advancing the science regarding recommending an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

The format for offering proposals, for discussions and testing for support using the gradients of support is listed in the charter. One reason for testing for support is to provide an avenue for each EFSAB member to share his or her rationale about their level of support and specifically, to address any concerns before.

1. Record each proposal separately for consideration and discussion
2. Check for understanding-*what questions do we have? do we all understand the proposal in the same way?*
3. Revise proposal as needed
4. List levels of support from charter
 - a. Level 1: Endorsement (I like it)
 - b. Level 2: Endorsement with a minor point of contention (basically I like it)
 - c. Level 3: Agreement with reservations (I can live with it)

 - d. Level 4: Stand Aside (I don't like it but I don't want to hold up the group)
 - e. Level 5: Block (I cannot/will not support the recommendation, decision, or proposal)
5. Poll for level of support of each proposal – *what is your level of support?*
6. Record level of support

All future meetings in 2013 will be held at the Stan Adams Educational Center.

A member of the EFSAB is requested to provide a summary at the end of each meeting. Bob Christian volunteered to share results at end of the Feb 19 meeting.

III. Brief Update on the Biological-Environmental Classification (BEC) System Study & Invertebrate Ecological Flows Study

Presenters: **Sam Pearsall, Environmental Defense Fund and Thomas Cuffney, US Geological Survey**

Sam Pearsall provided an update on behalf of Jennifer Phelan (RTI) regarding the Biological-Environmental Classification (BEC) system study, including preliminary indicators of how the study may inform the EFSAB's work and the anticipated timeline. The BEC (as presented by Jennifer Phelan at the Nov 27, 2012 meeting) is a dual path method to develop tentative classes, then biological response relationships for those classes based on fish data from water quality integrity data. There are 3 objectives for the BEC study:

1. Develop a new stream classification system based on geographical assemblages of aquatic biota (fish) and associated environmental (physiographic and hydrologic) attributes – Biological-Environmental Classification (BEC) system
2. Determine flow–biology response relationships for each BEC class (based upon biota that occurs within each class)
3. Identify which flow metrics are important for determining biological response, then link those significant flow metrics (and associated flow–biology relationships) to each BEC class to support ecological flow determinations.

Data sets are being assembled and thus progress is being made. The first draft is expected to be completed by the end of August 2013; the EFSAB is expected to hear about the BEC at the September 24 meeting.

Thomas Cuffney reported that the US Geological Survey and NC Division of Water Resources (DWR) have entered into a cooperative agreement to fund a study of the NC Division of Water Quality (DWQ) invertebrate data. This study will be conducted in concert with the Environmental Defense Fund sponsored RTI study of DWQ fish data (site classification, flow relations) and with ongoing ecoflow studies being conducted by the USGS Water Census in the Delaware River basin.

Questions (Q), Comments (C), Response (R):

C: A thank you to the agencies and organizations that are working diligently to provide additional data to help develop an approach to characterize the aquatic ecology of different river basins.

IV. Brief Status Report on 3-way Comparison for OASIS, WaterFALL and USGS Data

Presenter: **Sam Pearsall, Environmental Defense Fund**

During the Nov 27, 2012 meeting, the EFSAB supported the idea of Brian McCrodden, Sam Pearsall, Michelle Eddy, and Thomas Cuffney moving forward with a 3-Way Comparison of Oasis, WaterFALL, and USGS data. The small study ran into issues upfront:

1. Geographic coverage of OASIS and WaterFALL is dramatically different; OASIS covers gaged watersheds in NC; and WaterFALL is a statewide model.
2. OASIS is better correlated with gages than WaterFALL because OASIS is calibrated back to the USGS gages
3. The owners of these models are not going to pony up a lot of money to do 3 way comparison at this time.

Since the principal use for one of these models is to help us with classification and biological response, there is also a need for a model instantly available and statewide. At a recent water research coordinating committee, a decision was made to go with WaterFALL despite some of its challenges since it's the only statewide model. WaterFALL is not perfect. The belief is that as time goes by, WaterFALL will get better while OASIS will become geographically comprehensive. At time goes by, these models will become complimentary or one may surpass the other.

A 3-way comparison may not matter since the EFSAB is trying to develop a strategy. Later if there are better models and inputs system, the assumption is that the strategy will work but only better. Michelle Eddy (RTI) has looked at how WaterFALL ecological metrics compare to gage metrics and is reporting on this comparison this morning. today. Fred Tarver will follow Michelle with the benefits of comparing the hydrology of 9 hhabitat sites using WaterFALL.

Members of the EFSAB were in support of moving forward without the 3-Way Comparison of Oasis, WaterFALL, and USGS data given the issues the small study team examined initiating the small study.

V. Review of WaterFALL Ecoflow Metrics as Compared to Gage Metrics

Presenter: **Michele Cutrofello Eddy, Research Triangle Institute**

Presentation: [WaterFALL Metrics Across NC](#)

The facilitator introduced the next presentation, noting that there would be a 15 minute presentation, and then a few minutes for questions of clarification. She noted for those folks who are new, and guests, that the facilitators usually start off with questions of clarification, making sure that people understand what they just heard, then move into processing the information such as the implications of the information just heard. That kind of process of questions helps us think through the data and how we might use it. The facilitator then introduced Michele Eddy

Michele noted that she had two brief summaries. Sam had asked RTI to look at the ecoflow metrics but she also wanted to show something that RTI recently had been doing in trying to find better ways to validate WaterFALL. RTI is trying to participate in different validation studies as they come up so that they have other outside sources. RTI participated in a model comparison workshop that was organized by Pete Caldwell with the Forest Service. They had a grant to compare a variety of different models over the Southeast. They asked RTI for data for as many of 195 gages that RTI could provide, trying to focus on gages that were unregulated flows. They were gages of all different sizes. So we were able to provide 24 sites where we had models with WaterFALL to compare to the other models. They picked 24 sites. There several in Western North Carolina and then down into Georgia and the ATF basin there. These results are not fully released yet so I'm not going to tell you could not divulge what other models these are. The point was to compare WaterFALL with what Michelle called a complex rainfall runoff model, which used 24 sites, all of which they calibrated.

RTI compared against 12 sites that they had calibrated and 12 sites that were not calibrated, using their extrapolation method. They looked across 5 different flow metrics: 10th percentile: extreme low flows; 25th percentile: low flows; 50th percentile: average flows; 75th percentile: high flows; 90th percentile: very high flows. WaterFALL was very similar to this rainfall/runoff model that has a lot more higher-processing algorithms, a lot more details in it. Michele then showed results for one single gage, the Flint River in Georgia. There were 9 unique model runs, 6 unique models, A through F, and WaterFALL, with 2 of the models using different climate sets, and a little different prioritization. Same with D1 and D2. These are monthly flows. RTI wanted to see the comparison across all these weather models and WaterFALL; they found a lot less spread and bias in some months. They were pleased to see seasonal bias that you were seeing with some of these other models where they're over predicting in some months. This was a really successful test for us to show that what we are doing is a valid way to model.

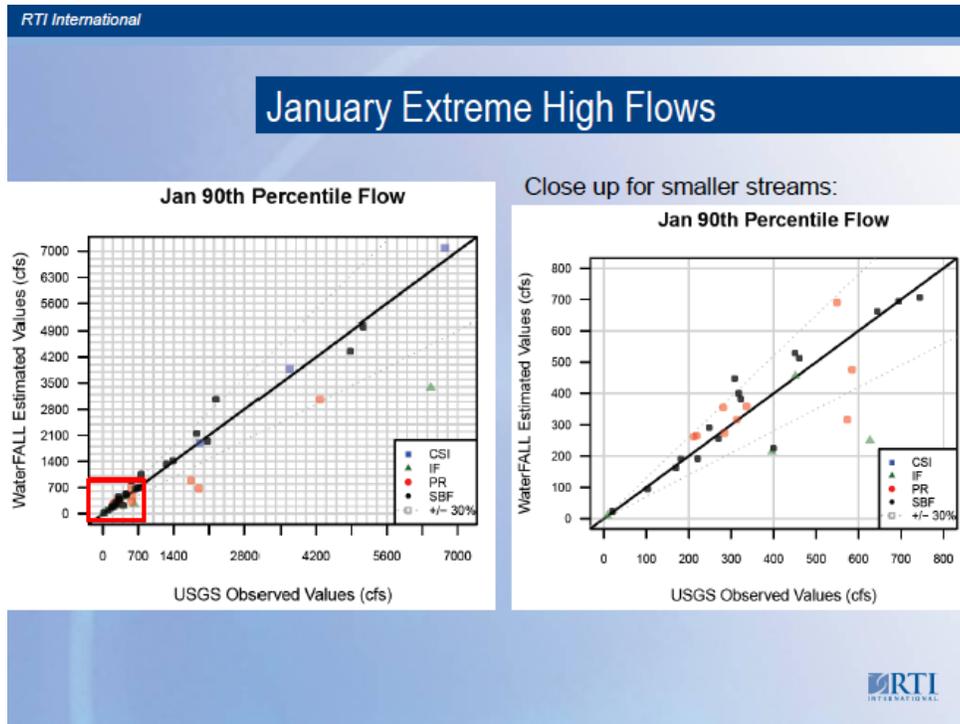
Q: Can you go back and explain the graphs a little more? What are the green lines?

R: This is percent bias so it's just absolute difference between the overall January average flow versus the gage January flow. So we have a box plot—the box itself is usually the 25th percentile and 75th percentile. The little red line in the middle is the median, while the green line is the mean.

Q: And that's for multiple years?

Michele: Yes. This was 1981 to 1999. The greens are the mean for the month. The red line in the box is the median. First year, as usual, a lot of information. EDF asked us to take a look across the state and look at these different ecoflow metrics to see how we perform. I went back through all the gages, and I tried to find gages that had about 30-year common period of record that spanned the gamut of things. I have reference gages, non-reference gages; I have gages that we actually calibrated versus gages that we just applied our extrapolation method to. I have gages that range from 9 square kilometers up to 6,000 square kilometers in drainage areas and then all different of the McManamay classification sites.

RTI pulled a little bit of everything to look at how are WaterFALL compared across all of these different types of locations and streams. They used the McManamay classification system because it provides a clear break between intermittent streams, perennial streams, stable baseflow streams. They ended up with a little bit of everything everywhere. Again, just trying to take a look—a big picture look at how we’re doing across the state. RTI has all 5 metrics for all 12 months available, but she showed a couple across the year to highlight, including the January 90th percentile flow.



The very faint grey lines on either side of the one to one line are plus or minus 30% bars. I was trying to find a close approximation of an ecoflow and at the meeting last week, it was tossed out there that 20 to 30 percent is good representation. You can see they were spread out around the line for the most part; we’re not highly overestimating or underestimating in this case. The little green triangle sticks out on most of them. I found out that’s because it’s a stream in the Little Tennessee where I had a return from a power plant, but I didn’t have the

withdrawal for the power plant, so that’s an alteration in there that’s making things a little bit off.

The different dots, the colors here again are going to break things up by stream clusters so you can see how, again, things are spread out. We have some small intermittent streams down at the bottoms, very tiny ones, stable base flows all over the place, and a couple larger of these coastal streams. Any questions, there? I’m going to go through, I think three more months and kind of pick some seasons here.

Q: You said that green triangle is the Little Tennessee? It’s not Rocky River Norwood?

C: That’s what I was thinking.

R: Yes. Sorry. Yes, it’s Rocky. It’s in the Little—

C: Yadkin.

R: Yadkin, okay. That one’s the Yadkin, there’s another green triangle—

C: I’m not surprised by the green triangle—

Michele: On Rocky River. It probably is, I wrote it up in my write up here so, I’ll have to go back and check my notes. Any other questions?

Q: The gold symbols, is that just a funky colored thing? What do they represent?

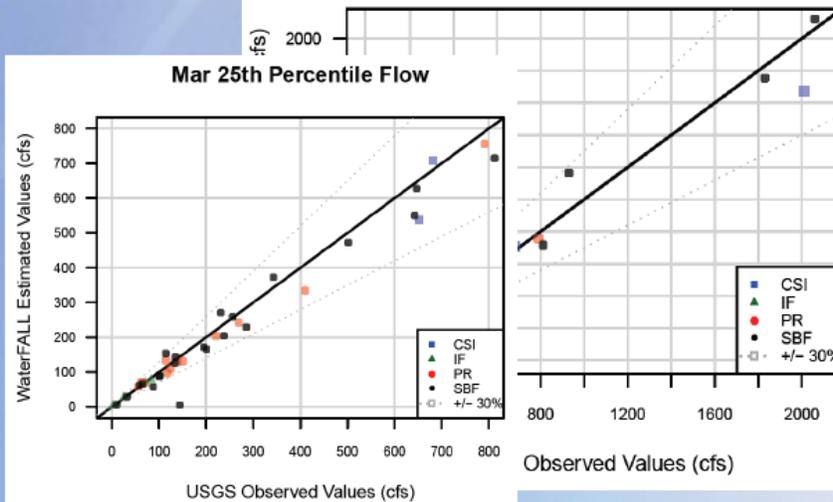
R: The blues are the coastal—The kind of orangey ones, I think they’re perennials.

C: It looks like in general it underestimates for the perennials.

Michele: And I should say, the 9 extreme high flows are where, if we were going to give something with the model, we didn’t expect to represent well, so I’m actually really, really happy with this because we do focus more on the lower side for our calibrations. I then picked the different percentiles across different months.

March Low Flows

Mar 25th Percentile Flow

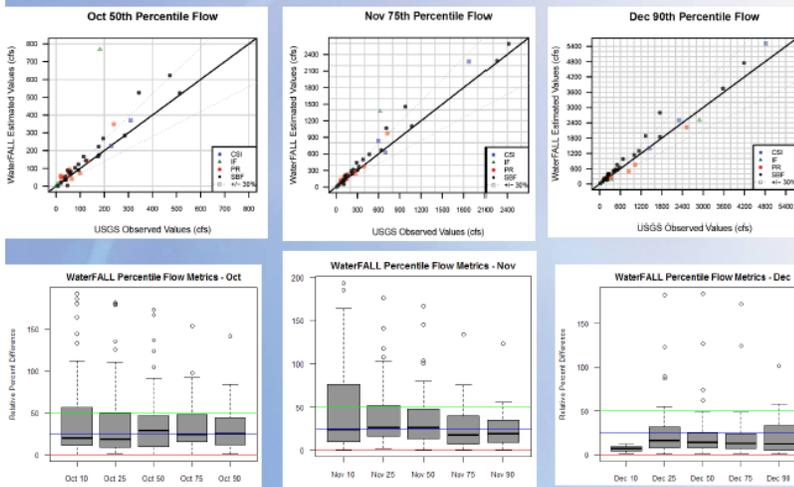


Michele then showed the March 25th percentile the low flows, noting that on all these charts, the grey lines are going to be 200 cfs intervals and just to provide a point of reference they included a couple of points all the way up in the 2,000 cfs.

WaterFALL bounced around the line, not really completely overestimating or underestimating. You pointed out the perennials were slightly underestimated, but they are right near the line. You would expect this to be within gage and model error. Okay. Looking at summer, (June, the extreme low flows), again, we have a wide spread. I

think the green triangle is probably that Little Tennessee one that I was talking about where I have a return amount of withdrawal. The graph on the right looks at the absolute values of the flows, showing the relative percent difference. So not just the absolute difference, but it's the relative percent difference—the formula that I'm using here is the absolute value of the difference divided by the average of the two values. So it gives you some concept of, "Is this a difference between two really low flows? Or is it a difference between two really high flows?" Because if you miss 1,000 CFS by 10% and you miss a 1 CFS by 10%—those are two very different numbers. This is an attempt to kind of normalize those differences and using absolute values, it's always going to be greater than zero. The blue bar is 25% difference and the green bar is 50%, just so you can get the line—just a little point of reference there.

Fall / Winter



Michele then showed box plots, which showed less than 25% difference for June, which is very good approximation. There are always going to be outliers. There's always going to be a few where, maybe, there was a storm event or something that we missed and we're always going to have a couple that just have some larger differences. Where RTI saw the largest variations in their estimations is in the fall and winter. They did not see it any one percentile across the flow regime, it's actually months. September, October, November showed the largest differences in the model.

September through November show the larger variations. They show a majority of the estimates below 25% difference with the gage. They got just

above that in a few percentile—a few of the metrics in a few of the months. We may be doing a little bit of an overestimation on the medium to higher flows. December brings it all back down to being a much closer representation of the gages.

In summary, the largest variation is not by percentile but by month with the most variation in fall (measured by relative percent difference--RPD): September, October, and November. There are always a couple outliers in each percentile in each month. There is some tendency to overestimate Median to Extreme High flows in September through November yet across the 51 sites the median RPD between the gage and model is <25% for all months and all percentiles except: Median to Extreme High flows in October (<30%) and Extreme Low to Median flows in November (<30%). Michelle guesses that for the fall the flashiness of storms, and especially hurricanes that hit in September, throw off the metrics a bit. We're seeing more variation there, and then there are always going to be those couple of outliers—a couple locations that just have water return differences. Sometimes data overestimate the higher flows in September and November, but still, as I just showed you with those relative percent difference graphs, we're still—when you look at all these sites together within a whole state, we're still representing most of them within 25% of the gage. These were our lowest performers where the extreme high flows in October were and the low to medium flows in November, which I just showed you on those previous graphs, where even though we weren't getting the majority of them under 25%, they were, you know, under 30%. It's still within those error bounds that we were hoping to see.

Facilitator: Questions of clarification on what you just heard from Michele?

Q: When you did your simulations, you didn't do them separately by month but it was through the whole time, so if you had a high—had a storm at the end of September, you should see a correspondence to the gage in October, right? In other words, you should see the state in both conditions.

R: We try to match those peaks but there are times when the timing just got off a little bit. Mostly, we do pretty well on the timing, so the storms jumping months would probably be a very slim chance of that throwing things off, it's really just those magnitudes, the peaks, because we try to—when we do our calibrations we use log space, which kind of normalizes out the differences --the error in the model that we're trying to minimize. So, when we do that, we tend to try to get the low flows a little bit better and we miss some of those peaks. If we focus on calibrating our peaks, the low flows go all over the place. That's why I always expected the high flows to have more variation.

Q: And just to follow up, that would be compatible with the ecological flows issues that we address, which tend to be more low flow than high flows?

R: Yes, that's why we were trying to do it that way.

Q: That green triangle--when you pointed out that that was Rocky River and when we were talking about that a little bit, it's not that surprising because this simulation used a 1970 land cover, is that correct?

R: This was all done with the current conditions. This was 2006 land cover, with any alterations that we had in there and I used the 30-year period of 1976 to 2006 to get a 30-year period to average all the metrics.

R: Okay, so 1976 to 2006 but with current conditions—

Michele: With current condition land cover, yes.

C: When you think about the Rocky River watershed, you've got Charlotte in the upper end, Concord, Kannapolis, and all that west—east of Charlotte land cover change that's been happening since '70, '80 whenever—which the gage is reflecting, which wasn't there in the early part of the gages. We're getting just a bit slow there accumulating through the record, whereas your simulation basically catches all that land change. Instead it had been there for the entire 30 years. Am I putting it correctly?

Michele: Yes. You're correct.

C: And so, you know, that kind of situation it is not surprising to see some issues.

Michele: Yes.

R: Because what do you do? Unless you have a constantly modifying land cover.

Michele: Yes. That's very interesting. I'll go back and look at that one year by year and see what sort of trend we're seeing in the monthly metrics, if it shows up there.

C: It's slate belt around there; it's a very low flow—Very flashy.

C: But it's not consistent throughout the whole—that's pretty much basin by basin.

C: But with all of the different underlying geology, it's not surprising that one would be a hard one—you've got a gage at the bottom end of that whole basin essentially. So you're accumulating different things going on in different parts of the basin, unless the land cover changed.

Q: So just one other question—you said Little T, you're talking about a power plant. It might be that Lake Franklin is operating and is deducting that in certain tests, but to that—

Michele: I'll go back and clarify some I'm missing and send you an e-mail.

C: About that land cover thing again, you're kind of damned if you do, damned if you don't. What WaterFALL does is try to use current conditions, figuring that that's what's going to be going forward more so than the old land cover. OASIS is calibrated to gage records. So, if you've got a long term gage, it's calibrated to the whole smear of land cover changes that have occurred over time and assumes that that pattern is going forward into the future where actually, it may be the most recent and the years of land cover, the last 10 or 15 years event, 80 year OASIS record that is more likely to go forward in time. Not to say that one or the other is better, but it just points out that challenge you have there.

Michele: And we do have other land covers. Like you pointed out, we can work with the 1970 land cover.

We're experimenting with that. Jen's also tried out the potential natural vegetation land cover to look at changes across from completely no humans to current day.

C: I was going to propose a confidence vote on WaterFALL because the BEC's going to be using WaterFALL. And it seems like, if we can get consensus, that we don't necessarily need any additional presentation on the quality of WaterFALL, that maybe we are there, that we have confidence, and we can go forward.

[The facilitators suggested waiting until after Fred's presentation to consider that.]

VI. Benefits of Comparing the Hydrology of 9 Habitat Sites Using WaterFALL

Presenter: **Fred Tarver, NC Division of Water Resources**

The powerpoint presentation can be found at [Fred Tarver's Comparison of WaterFALL and OASIS](#)

Fred's presentation is a comparison between OASIS and WaterFALL, but coming at it from a different approach, from a habitat point of view. To review first, PHABSIM—is a physical habitat simulation as a component of the IFIM process, Instream Flow Incremental Methodology. You may recall Fred emphasized that we have in the state 9 PHABSIM study sites we selected to use, and they were based on the fact that we had the OASIS models for these basins, and they were fairly good with the model. These 9 sites are associated with water supply, primarily. Some were run of river, some were reservoirs, one was actually nuclear power. Most of them were originally run using gage data, either a proximal gage, or were referenced to a nearby a gage. These were done many years ago, and what Jim did was resurrect them using the current OASIS model that was generated for the particular basin. DWR has 30 plus sites in the state. The 9 that Jim picked were actually for one reason, the presence of the OASIS modeling. Also, for some of the 30 sites we have data format issues, and some are associated with dam projects that altered the flow. What Jim did was look at a spectrum of flow releases: traditional flat flow types to a monthly median at the to percent of flow by as your flow requirement.

As part of the validation and verification of WaterFALL, at our last meeting, we talked about whether within DWR, we should take WaterFALL flow record and re-run these 9 in stream flow study sites and do a comparison of the habitat responses to what Jim did with the OASIS flow record. There was some discussion about that, and it was determined that maybe it might be better just to look at the statistics of the two flow records. Maybe you don't even have to do the habitat, re-run the habitat models, because if there is close agreement between stats of the two outputs, then maybe if they're so close, you don't need to run those models. So that's what I did.

Fred used 9 flow records from WaterFALL at the 9 instream flow study sites. The period of record was from 1961 to 2006. For the 46 years of record, he compared all the months for the 46 years and looked at the median. Looking at the First Broad River Middle you can see the little whisker chart shows the median; then the Q1 and Q3 are the 25 and 75 and then you have the min and the max. For the most part, WaterFALL and OASIS seem to track fairly closely together. I did not do any statistical analysis to determine the goodness of fit, but "eyeballing it" it seemed to fit fairly well. It looks good in August, September, October.

C: Not that it matters, but I really think that's the 10th percentile and 90th percentile rather than the min—

Fred: Oh, is it? I think they do represent min-max. I believe.

R: It would be nice to know if there are a bunch of outliers above those lines or not. So, I'm real curious to see if they really are min and max.

Fred: Okay. I'll check that.

Fred: Both First Broad lower site and First Broad Middle track fairly well. There is a little bit of range in the outliers, a little bit. For the First Broad upper site it tracked fairly well. Now I picked a few that didn't track very well, such as Rocky River. There's a little disparity.

Q: And that's a different Rocky River than Michele's green triangle?

R: Yes.

Q: Is it intermittent? Or perennial?

R: A small flashy.

Q: Is it in the Triassic Basin, I guess?

R: Yes

C: I think its 7Q10 was about 0.3 when we were working out there, so it's a pretty low flow stream.

R: Yes.

Q: Is this a river basin that has experienced a fair amount of development?

R: I don't think so.

C: They probably expanded reservoirs during that time period.

R: They did.

C: It's also difficult for OASIS, I suspect, to be developed for this watershed because there's very little gaging.

R: But I wouldn't classify this watershed as being highly developed.

C: In terms of development, it probably has more ponds, farm ponds, and evaporation affecting the hydrograph more than the runoff.

Q: So for that period of record, '61 to 2006, do you know how Michele ran through WaterFALL? In other words, did she have a constant land cover?

Fred: She used 1970 so that might be a somewhat of a confounding factor.

R: Well that is why I'm asking. How did OASIS do it over that period of record?

R: OASIS just calibrates to whatever gages are there for those years.

C: You might be missing that to some degree.

C: That was my suggestion, to use the 1970 land cover, splitting the difference. OASIS covers the land cover

before '70 and after '70 and kind of, again, splits the difference.

Fred: I think I addressed this toward the end, but I was thinking that land cover, for some of these, probably wouldn't be that much of an impact because some of these are below reservoirs so I think that might have a dampening effect to some of those effects of land cover.

R: No. This is all unregulated, though.

C: Well, some of these watersheds haven't experienced that much development, in like the Rocky River and some of those other—

C: In my presentation later today, one of the things I'll show are contemporary changes over time and in Little Tennessee, it has some of the recent amount of change that might be attributed to land cover. So this is one river. We'll have more consistency in the gage data from 1960 up to 2006. The land cover may not be as big an issue for this basin. Again, my analysis will look at the statewide comparisons for Little Tennessee, at the least.

R: We need to talk to Michele and see if we can get an update. If she has a more updated version of development, then I should get that.

C: There just may be a stream class, a McManamay class that is not as tight in the modeling between WaterFALL and OASIS, and I think your point about the gages, frequency of gaging, on a given system may also be a question, but that in and of itself, I don't know that it's a reason to throw the baby out with the bath.

Q: Was this one you pulled aside because it shows the most difference out of the 9?

Fred: Yes. For the most part; this is Eno River State Park, the site the EFSAB went out to. But there's a little bit of diversion, too. I did not do the statistical analysis to see if it was significant statistically but just based on eyeballing, it was a fairly decent match. I pulled out a few sites just to illustrate some of the divergence there. Next I did linear regressions for comparing OASIS to WaterFALL. I had distributed a paper to the EFSAB that had discussed the error associated with models and gages that were, as Michele said, between 20 and 30 percent, plus or minus, as a range, which, as Fred pointed out, could be a fairly wide range of flow.

Fred then showed the linear regression for the Tar River. He had picked some to illustrate various points, but it depends on what your standard is. Fred had seen one paper where anything larger or greater than 0.5 was acceptable, by which standard, the Tar River site is a fairly decent fit.

Q: Did you by any chance drive any of these through zero and see what the r-square was?

Fred: No. I can do that, though.

R: Because I wonder whether your slope would then start approaching 1.

Fred: I was debating about whether or not to do that, and I just went with the non-zero intercept. I might do that. I went with the best and the worst—the Rocky River is the worst amongst the various comparisons. These are all the 46 years by month. So there's 12 times--.

Q: Again, is this Cape Fear?

Fred: Yes, Rocky River in the Cape Fear. So there's not a great fit here. As you can see, a lot of these had a single or two out-liers which was interesting. Looking at the Eno River State Park, you get clumping at the bottom and then you have a few outliers up higher for some reason. You might be able to massage the data a little bit to get a better fit. You may be able to eliminate some of the outliers. Looking at First Broad River, the lower side, it was interesting because most of the points fell within the plus or minus 30% and had a pretty decent fit. Tar River had another lumping at the bottom and then an outlier--not a great r-square. Buckhorn Creek, which is below Shearon Harris nuclear plant, they're all the way down at the bottom, and then you have these few outliers, even though it still had a pretty good r-square.

Fred ranked the r-squares, and the best of the r-square in terms of number above 0.5 was Buffalo Creek and the worst was Rocky River. I did notice that February for some reason always seemed to fall out at the bottom of the r-square values, not all the time, but it seemed to be fairly consistent, and April seemed to be closer to the

top as well. I'm not sure why that is, but I kind of noticed that in preparing the slides. That wasn't based on statistics either. I didn't go back and check the elevation models, but I'll assume that they'd have similar drainage areas. So next step? Additional analysis required? Jim and I were talking earlier—maybe just proceed with some of the worst case scenarios and see how well they fit?

Questions? Comments? To reiterate, the reason why I did this was to compare statistically the record generated by OASIS and WaterFALL to see if there was a need to run the time series. The question is, is there a need to still do some of those? I think it would be interesting because you really can't tell what the habitat response is just based on flow record. Not sure we are expert enough to know what the habitat response would be just based on the flow record, but it would be kind of interesting to look at. Like I said, pick some of the worst cases and see what they look like.

Q: Can you just explain the second assumption, on your last slide, about similar drainage areas?

Fred: I gave Michele the latitude and longitude; she gave me back the flow records and she gave them to me in terms of number catchments. I didn't try and construct the topography based on that elevation model, so I'm assuming that my point is where she stuck her points and generated the flow record.

C: She can only give you the closest catchment to where ever that model is, so you don't know—

Fred: I think a couple of them indicated that she was slightly higher in the watershed so I think you were a couple that weren't quite at that point. Whether it's significant or not, I'm not sure. So that's what you are asking?

R: Yes, because usually, like with the 7Q10's and everything, there is a relationship between drainage areas, right?

R: Yes.

Q: High correlation?

R: Yes.

Q: So I wonder if what Michele said about certain months, her analysis, overestimating, if you saw the same in your box and whisker plots, that same thing?

C: It did look like that on there was pretty heavy extremes, which the month she plucked out—those months when you have really, really low flows and then have a hurricane, the—

C: I don't know if it was more—

C: In February it should have been really low; February was in the high.

C: Except for the Rocky River looked at its greatest differences in the spring.

Facilitator: I heard a question regarding next steps: is additional analysis required, because you could go through and finish the habitat series with the WaterFALL, is that's what's on the table, am I correct?

Fred: I could go back and compare the two more in depth in terms of what Michele did by looking at the statistics of the flow records themselves. Or I could delve into the time series analysis and pull a couple of the sites out, like some of the worst cases, as Jim suggested earlier, maybe by Buckhorn or Rocky River to see how they respond, since they're the worst case—see if there's a big divergence in habitat response whether run with OASIS or WaterFALL.

Facilitator: So if there was that level of confidence then you would possibly use WaterFALL when you don't have an OASIS model.

Fred: Exactly.

C: So there's this question of whether you go ahead and do this in PHABSIM analysis to decide whether or not we're comfortable using WaterFALL, or we may already be comfortable using WaterFALL without the further analysis. I'm wondering if DWR is going to be comfortable with WaterFALL without doing the further analysis.

Fred: Well we do have scripts of time put together to look at OASIS output in terms of gages. I'm not adept at R so I'll have to get Tom to perhaps run those; think there is a quite rigorous test that he set up so that would probably help a lot in terms of comparing the record that Michele provided and OASIS that I used--run it through the R and see how well they fit. That would be another approach and pretty quick.

Facilitator: I'd be interested in hearing some reactions to the proposal of doing a little bit more analysis on WaterFALL.

C: I am flummoxed. I've seen one presentation which basically says that WaterFALL fits USGS. Now I do not see a good match in a lot of cases between OASIS and WaterFALL. What are we really trying to predict that we need to have? I don't see the benefit of going through all the gyrations for the PHABSIM until we've worked out why WaterFALL and OASIS are not matching up. Are they really predicting the same things? the same time periods? using the same data? Or is there something in there that's causing them not to match up? When I see an R-square of 0.2 and a slope of almost 3—they're not going to match up. ***But I don't know why. What's critical to me to understand, going forward, is why we're seeing the differences.*** Why is WaterFALL on the one hand—now remember it's only 24 sites that they looked at and there weren't 24 sites in North Carolina that showed good correspondence to the USGS gages, and there's OASIS which I assume the state has a great deal of confidence in, but now WaterFALL is not lining up with that in certain circumstances. So it seems to me that before we move on with a more in depth analysis of the PHABSIM, we need to understand why they're not matching up.

C: I'd add that those sites in Georgia, down at the ACF that Michelle used to balance the ones that weren't in western North Carolina are in highly developed and rapidly in developing areas. So they suffer from that same land cover fixed bias.

C: I'd like to play off on an earlier comment that Judy made. As we start moving forward to making our recommendations and conclusions, I hope we're not going to be limiting the tools that are available to the Division of Water Resources as we begin to determine ecological flows. We've clearly got a couple of models here; there is not truth in either one of them. They are reasonable in agreement with each other, similar to the way many other models are reasonable in agreement with each other. Do we need to continue to dabble in the weeds about the validity of these models? They are both going to change over time, and the Division of Water Resources, based on site specific permit requests for removal of flow for various reasons, is going to end up using the best tool that they think fits that particular request and site. They will clearly be using both of these as long as they're both on the table. I think we can begin to spend less time on the details of the two models and move on to other issues, such as the biological relationships and the classification relationships. And I'm pretty pleased with what we've seen on both of them.

C: I was just going to respond a little bit to what Tom Cuffney talked about in terms of why is—Michele's presentation is very encouraging and then Fred's was a little bit discouraging for some of those 9 spots that he evaluated. It occurs to me, if WaterFALL had come first, we might be wondering if OASIS was good enough. But because OASIS was done first, we're wondering if WaterFALL is good enough. Just to eliminate, Buckhorn Creek was one of the worst bits there. And in talking with the folks from Hydrologics during the Shearon Harris exercise, they had a heck of a time developing the OASIS model for Buckhorn Creek. The USGS gages have horrible problems with beavers. Most of its record was influenced by Shearon Harris dam, and they were trying to create an unregulated record for that creek. So they had to try to back out the effects of this massive reservoir upstream of the gage.

C: Which had no flow requirement.

C: Right. What they ended up doing for most of that record, for the OASIS simulation on Buckhorn Creek, is they extrapolated from the middle gage, over in the Neuse Basin because that was the one they found had the best fit in a tiny piece of unregulated record they had for Buckhorn Creek. They had to do a lot of gyrations to come up with something for Buckhorn Creek. WaterFALL just did their land cover rainfall runoff model and

that's it for Buckhorn Creek. We know that OASIS had to do a whole lot of gyrations to come up with something. In the Rocky River, there is little gaging there for OASIS. They had Tick Creek, which is a tributary to Rocky River; it has a very long record but it has many zero discharges. It's a small, extremely flashy slate belt stream, and it's a lot smaller than main stem Rocky River. They've got a gage on Rocky River but haven't been there very long to help the OASIS model. So it may be that it's not just a problem with WaterFALL. There were some challenges for OASIS as well coming from that direction. Instead of doing all 9, given its arduous process, try to compare habitat as opposed to what you did with just comparing cfs to cfs, pick 2 to 4. I would not pick Buckhorn Creek because of problems with OASIS there, but if you wanted to look at Rocky and maybe Eno State Park and maybe one of the First Broad Rivers sites to see what about one had a good fit? Did we also get a habitat there? But pick a couple and just put the nail in the coffin.

Facilitator: There was a semi-proposal that came up before Fred's presentation. This might be a good time to think about testing a consensus principle with the use of WaterFALL.

C: I'm not sure we need a consensus principles or a confidence vote, for WaterFALL. The project we're doing over at RTI is going to use WaterFALL because it's the only model with statewide coverage. Meanwhile, the state continues to make its decisions, plans, and develop perspectives using OASIS because that's what they have. In time, these two models—will converge as we get more experience with each of them. I don't think the EFSAB needs to vote on which one it likes better, or whether it has a high level of confidence in either or both of them. What matters is that we put forward a strategy for using a model and a set of biological response data to develop a system of ecological flows, and develop a consensus around that strategy. The strategy will get better as the models get better and the data become more plentiful.

C: For me, the benefit of a proposal about confidence in WaterFALL is having an understanding that we do not have to take more time away from board meetings discussing the qualities and the abilities of WaterFALL or OASIS to support our efforts. We're already using WaterFALL; we anticipate using WaterFALL, and we're awaiting the results in September. If there are substantial concerns on the Board about WaterFALL, that might undermine our ability to accept the results. I would say I have confidence that using WaterFALL is an appropriate step but would prefer not to wait until September to discover that there is a substantial lack of confidence in WaterFALL's output such that the Board cannot support the results of the classifications.

R: I withdraw my remark.

Facilitator: You don't need to withdraw. Here's my suggestion to move to our next agenda item. Would you be willing, Judy, to draft a statement that could be posted for the group to test for consensus? Could you develop it during lunch for discussion after lunch?

Other Facilitator: Are there other comments with respect to WaterFALL? And has DWR gotten the information needed?

Fred: Yes, DWR has what it needs. There were suggestions about proceeding with some of the PHABSIM comparisons. And I think some of the R stat programs that Tom Fransen has will help illuminate some aspects. It's a more rigorous statistical analysis than used for OASIS. While I do not have a clear thumbs up or down, I don't know that there is a real need to delve more into the line of approach I am considering. I don't want to invest a whole lot of time in creating more box and whisker plots. Not sure what it would prove or how it would move us beyond where we are right now.

Facilitator: If anybody has thoughts, suggestions about which land cover to use if DWR decides to go ahead with this comparison at a couple PHABSIM sites, now would be a really good time to raise those suggestions. Right now, as it stands, Michele uses the 1970 land cover. Is 1970 the best, splitting of the difference, or does somebody else have a better idea?

C; It might be a good comparison to use the updated land cover and compare the '70s to the current.

R: I'll think about that. I don't know if I could get too rough around the edge around the land cover because, you

know, unless you're in a very small basin that has a huge amount of impervious cover, the effect of the land cover is going to be a lost in the noise of the model's fit and everything, so 1970s is fine and, you know, we run a number of simulations changing land cover. At this scale, you're not even going to be able to detect; it's not really worth chasing that problem, except for very small basins with a lot of change in land cover.

R: Or potentially those that are more than 15% impervious already and those are going to show up.

Fred: We typically don't work in highly urbanized studies.

R: Most of the sites that you're talking about are not like that. A question was raised concerning the box & whisker plots Fred presented: were the whiskers indicative of 10/90% or min/max? The whiskers do represent the min/max monthly median values. (Fred constructed the plots with monthly median value output from IHA by year of the period of record and selected the extreme, 1st and 3rd quartile and median values using the QUARTILE (0-4) function in Excel.)

Waterfall Discussion: Support of Confidence for WaterFALL (note: discussion occurred after lunch)

An EFSAB member proposed testing the level of confidence members have for the use of WaterFALL. The purpose was to assess how comfortable the EFSAB was with the use of WaterFALL (regardless of BEC and not to the exclusion of other models like OASIS), and possibly decide if there was additional work or analysis that would help to move forward using WaterFALL as an adjunct to OASIS. A question was developed by several EFSAB members during lunchtime. The EFSAB was asked to provide their level of support for this statement:

How comfortable are EFSAB members with WaterFALL being used as a tool moving forward in this process?

(meaning using it in general regardless of BEC). EFSAB members provided their level of support as follows:

Scale	# of Members
1-Fully Support	1
2- Support with minor concern	11
3 –Live with it but have several reservations	2
4 – Abstain; cannot support the proposal due to major reservations	1
5 – Block the proposal	0

The results showed that most EFSAB members had a fairly high level of comfort with WaterFALL being used as a tool moving forward, with 2 indicating that they could live with it, and 1 indicating they were not comfortable with the statement but would not block the proposal from moving forward.

Facilitator: The rationales levels of support at 3 and 4, included:

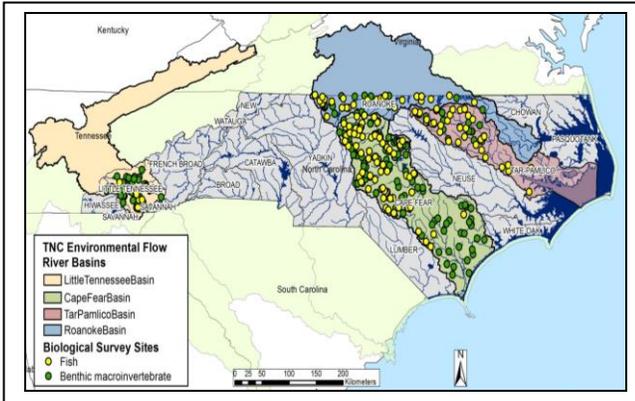
- The statement is limited; by it we do not mean that WaterFALL is the only model we support but one of the models supported. We do not want to limit our recommendations to NC DWR since we are advisory and they will need to decide what works best for them.
- Unclear how good WaterFALL is; hasn't been thoroughly tested where it hasn't been calibrated (to gages)
- It's still not clear how the EFSAB will move forward with the coastal plain. Another concern and unknown is what will the cost be of using WaterFALL from the perspective of DWR.

Some discussion occurred where members explained that the recognizing the support of confidence was intended not to limit the use of other models that DWR can consider but to make explicit the comfort level with WaterFALL.

VII. Update on the Nature Conservancy Environmental Flows Project for NC

Presenter: **Kim Meitzen, The Nature Conservancy**

Presentation: [Update on the Nature Conservancy Environmental Flows Project for NC](#)



Kim Meitzen, PhD provided a presentation to update the EFSAB on the TNC Environmental Flow project. This project's goal is to identify stream reaches with the greatest resiliency and conservation potential for supporting healthy biodiverse freshwater ecosystems. The environmental flow study is one part of the TNC's Freshwater Resilience Project.

Kim developed a 5 step process for decision support.

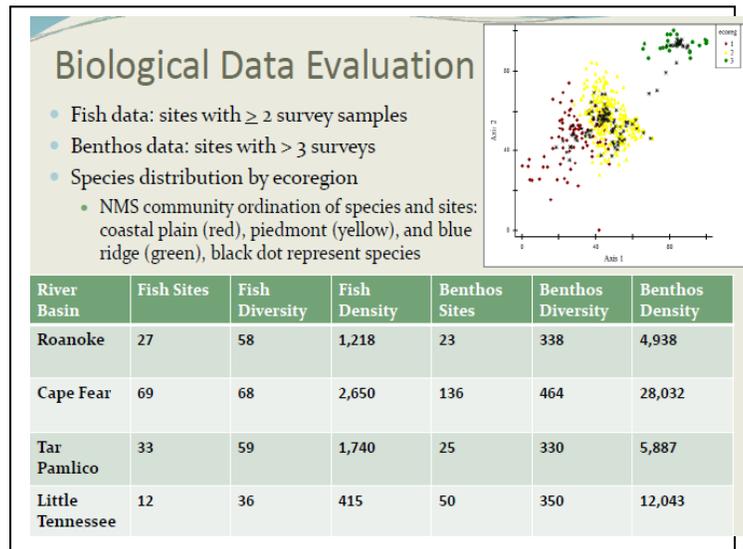
1. Conduct literature review to develop flow-ecology relationships for NC riverine biota and physical stream processes (have created a database of ~384 references)
2. Analyze changes in (a.) flow patterns and (b.) biota over recent history of flow impacts
- 3a. Identify patterns of biotic changes
- 3b. Identify spatial and temporal patterns of flow changes
4. For TNC, develop flow-ecology criteria and flow recommendations to protect riverine ecosystem integrity characteristic of NC's biotic and physiographic diversity (created a Decision Support System for Environmental Flows -DSSEF)
5. Identify areas of conservation priority relative to freshwater ecosystem resilience and vulnerability

Additionally, she hopes to provide information and resources/analyses to the EFSAB to assist their environmental flow recommendation process.

So a quick review of biological data evaluation. Looked at DWQ data for Wadeable streams.

- Fish data: sites with > 2 survey samples (1990 - 2011) yellow dots on the map
- Benthos data: sites with > 3 surveys (1982 - 2010)- green dots on the map
- Species distribution by ecoregion
 - NMS community ordination of species and sites: coastal plain (red), piedmont (yellow), and blue ridge (green), black dot represent species

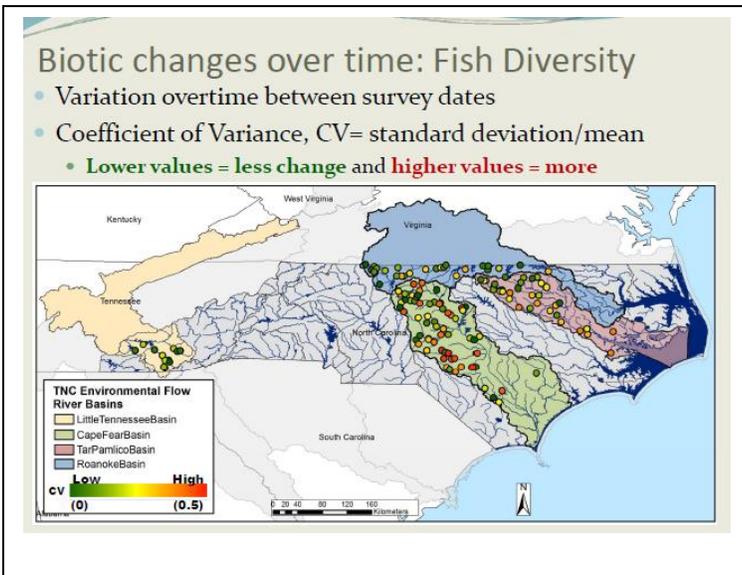
I looked at these species in for 4 basins- the Roanoke, Tar-Pam, Cape Fear, and Little Tennessee Basins- this is number of fish sites that met the criteria for fish and benthos (see map). The idea is to see changes over time.



With this selection we had captured the compositional variability of species in the state compiled by ecoregion (see graph on Biological Data Evaluation slide). Coastal plain (red)- characteristics are similar in those sites,

piedmont (yellow), and blue ridge (green), black dots represent species. There is a gradient and a general spread in that so we captured geographic distribution and species community distribution.

NCWRC worked in assimilating a guild based reference for the state. I looked at all the different fish sites and percent of fish types in guilds. Some of the guilds were combination guilds (**slide fish distbn**) Among all the sites I looked at, 10% were in backwater guild, pool guild- 37%; pool run- 29%; riffle-9%; riffle-run-14%. There weren't many in the pool margin (1%), this may be a guild that can later be collapsed to have 5 guilds rather than 6 and reduce some of the variability we see with that. Distribution across sites shows it was well represented by guilds.



Biotic changes over time: for all sites I looked at change over time, produced these graphs.

- Fish and benthos diversity and abundance changes over time
- Graphs for 141 fish sites and 234 benthos sites
- Calculated Coefficient of Variation (CV = st.dev of difference/mean) to show variation in both diversity and abundance among sample surveys. To show which sites changed more.
- Contemporary conditions and patterns of change

Next graphs will show spatial projections of those patterns of change using CV.

In all the graphs color- green=lower change over time (of either diversity or abundance depending on the slide). Red= high amount of change. For the Fish Diversity map, Little TN stays fairly green- yellow, between the sample dates there has been the least amount of change there. Areas in Cape Fear and Tar Pam are redder, there has been greater change at those sites over time. It's a good snapshot over time. Same key for abundance- not much change in abundance in Tar-Pam but we saw diversity change a lot. In Cape Fear a lot of change associated with abundance (ADD SLIDE?), Dan River headwaters (the NC component of the Roanoke) saw very little change.

Q: what were differences in times of those survey?

R: Vary by site, roughly ran from 82- 2011. Some sites would have a lot of survey locations and others had less. (I showed in my Oct 2012 presentation).

Presentation continued:

For Benthos had more sites, 234, (showed slide- benthos diversity)

On fish diversity and CV only ranged from 0-.5 (CV can range from 0-1.0). Benthos' CV ranged from 0-.99. This indicates a larger rate of change associated with benthos communities. Benthos communities have been more sensitive with regards to diversity and abundance.

Benthos diversity and abundance- same pattern, to give you idea of what distribution looks like. Little TN shows least amount of change- more stable; a lot of change in Cape Fear, Tar-Pam and headwaters of Dan are greener, more stable. This doesn't show + or -, just % change that has happened.

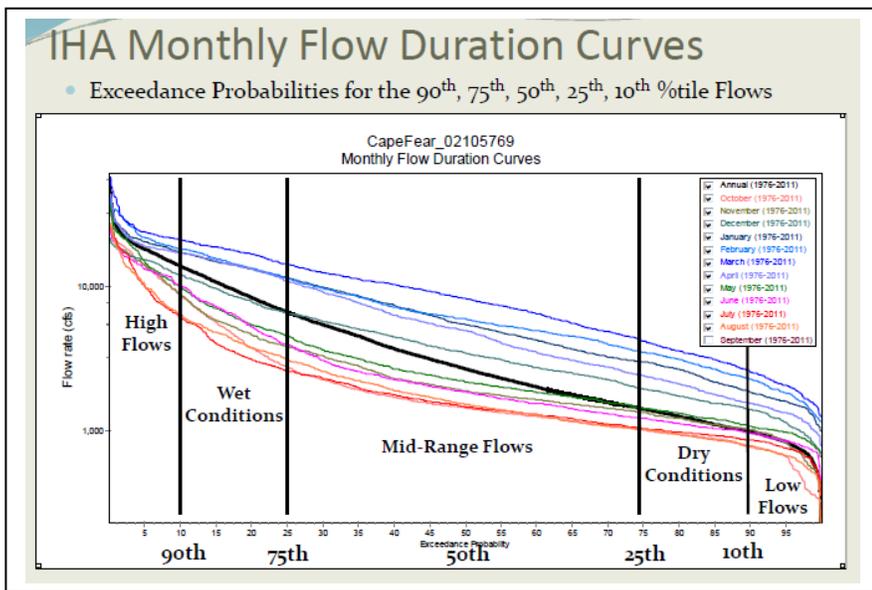
A couple patterns to point out – to see which sites are resilient and stable and which ones are changing more frequently. Shows a quick snapshot of what current conditions in the biota looks like, and how they have been changing just over the contemporary time period.

- Little TN is more stable
- Dan River, a lot of relatively stable conditions and not a lot of changes of biology
- Some areas of Cape Fear have seen a lot of change
-

Second part of analysis- flow analysis. Initially were going to use WaterFALL approach, but ran into issues with contract/timing issues, so went with USGS Stream Flow Gauges instead. I filtered to pick out gauges in the 4 basins.

- 34 gages with 36 years of record, 1976-2011 (divided it into 2 periods of record)
 - Period 1 (I refer to as recent historic conditions): 1976-1994
 - Period 2 (I refer to as current contemporary conditions) : 1994-2011
- **What are the changes in flow patterns over recent history (1976- 2011)?**
- **How do they vary spatially (among gaging sites) and temporally (months)?**
- Gives a snapshot of contemporary conditions and patterns of change

Important thing to look at are bullets 2-3. This can help us look at which areas are more stable, which areas are changing much more. I had a good distribution of USGS stream flow gauges in the 4 drainage basin areas of my study spatially (showed a slide with table of all gauges), there was a good diversity of what I was looking at so there wouldn't be too much bias for one ecoregion or area over another.



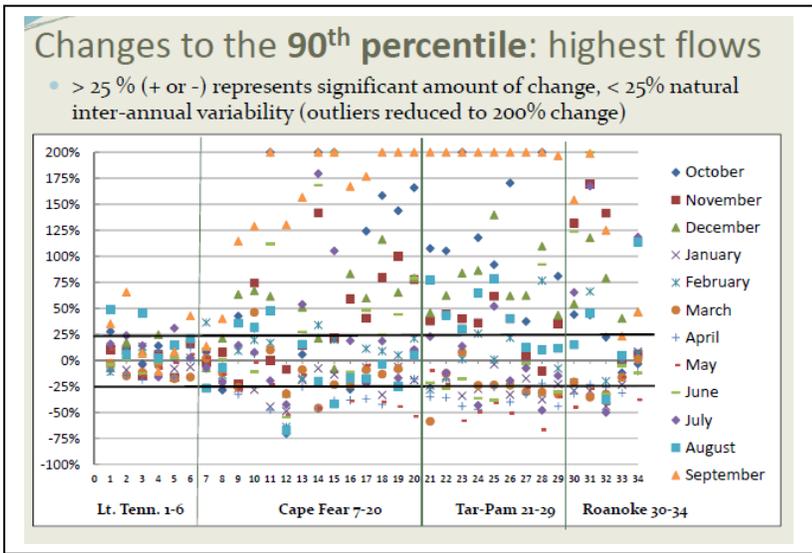
I used Indicators of Hydrologic Alteration (IHA) software for analysis, used to look at standard metrics, and environmental flow component metrics (EFCM), to compare that historic and contemporary change over time. Today I'll just go over monthly metrics (of 90th, 75th, 50th, 25th, and 10th percentile flows) for time's sake, and also monthly metrics are more amenable to management so seemed most relevant for this group. The analyses have been done for everything else though.

Here is an overview of how to read a

flow duration curves and percentiles:

- 90th percent are highest flows (occur during highest discharges)
- 75th -25th represent mid-range flows
- 25th - 10th are dry conditions
- Lowest 10th is extreme low flows (you don't want to get to those).

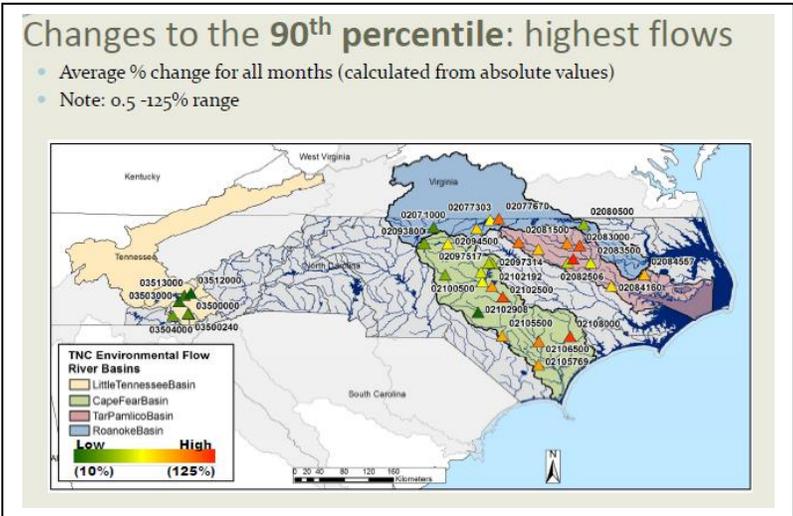
You have the extremes on either end. The spread from top to bottom represents monthly flow duration curves across the year (wettest months on top, driest months on bottom....gives you idea of variation within months, and variation across the range of flows that occur over a year).



We'll look at changes over these 5 conditions. This shows how it looks (see graph of Cape Fear Monthly Flow Duration Curves). See Black line—in this case the contemporary flow is much higher in 90th than historic. On opposite of that extreme, current flows are much lower in the 10th percentile than historic. I'll show you tables that measure what this amount of % change is (note that the maps do not show whether change is positive or negative).

Kim showed 2 slides for each of the percentiles (90th, 75th, 50th, 25th, and 10th percentiles). The slides for the 90th percentile are shown below as examples. The 2 slides for each percentile included:

- A graph of all months that shows % change, whether positive or negative. More than 25% is significant change, less than 25% is assumed due to natural inter-annual variability (this is the area shown between the black bars- above bar is significant + change, below bar is significant - change). Outliers were capped. The gauges are grouped by basin, and goes from smallest drainage area to largest.
- A map that shows average % change (of absolute values) for all months, with the range indicated (does not indicate whether change is positive or negative). These were created using IHA graphics.



Notes about 90th Percentiles flows: Outliers were capped to help with visual, Change within the bars is due to natural variability. Below bar, significant negative change, above topbar, significant positive change. Grouped by basin, within each basin, goes from smallest basin drainage area of gauge to largest. One thing that jumps out is Sept, Oct Nov flows, 90th percentiles all increased (high flows are higher). A lot of the extremes we see more intense- could be more intense precipitation or more intense flashiness due to landcover change.

Map of 90th percentile: Little TN not much change, other basins show areas with less change some with more change. This presentation will be posted so you can pick out more patterns or details.

Notes about 75th percentile flows: Nov. always higher. Aug, always lower. There are a lot of patterns that we see. Anyone have any ideas why we may be seeing higher September flows vs lower August flows?

R: Irrigation schedule- essentially ends about end of Aug. A lot of stresses in August are due to water demand. Sept flows are much higher because water demand has ended. That's also a big extreme from one month to the next.

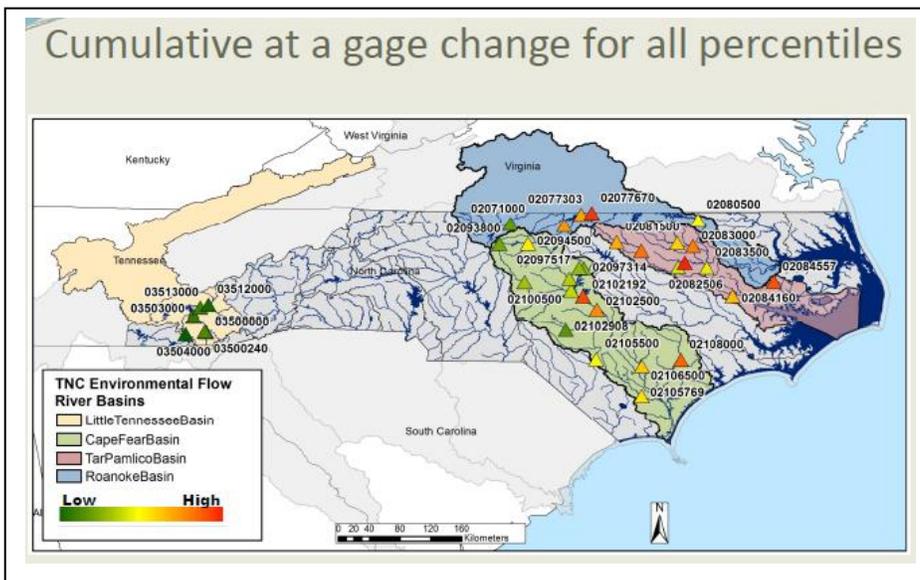
Notes about 50th percentile flows: There is actually a lot less spread, a lot more of the change falls within the natural variability, which might indicate that mid-range flows may not be as good as an indicator for measuring ecosystem response because it's not as sensitive as some of the extremes, or the 25th and 75th percentiles may be more useful than using median 50th percentile flows. Again the spread with August really low, Sept. on the higher end.

Notes about 25th percentile flows: Just a map of those distributions, 25th percentile flows (slides) dry conditions. Just a few more minutes.

Notes about 10th percentile flows: these are our lowest flows. You see a lot of stress associated with certain months, Aug, Sept, Oct, July. These graphs give you a way to look at what current contemporary patterns of flow changes are, one can use it to help inform decisions, using different flow percentiles.

It's important to know these gauges are above major reservoirs, they don't have that dam influence associated with the changes in flow, **the other ones do. (facilitator is unsure as to which these refer?)**

The cumulative changes for all percentile flows was shown on a map: Tar Pam sticks out because it has a lot of impacts from water use and not power use/dams.

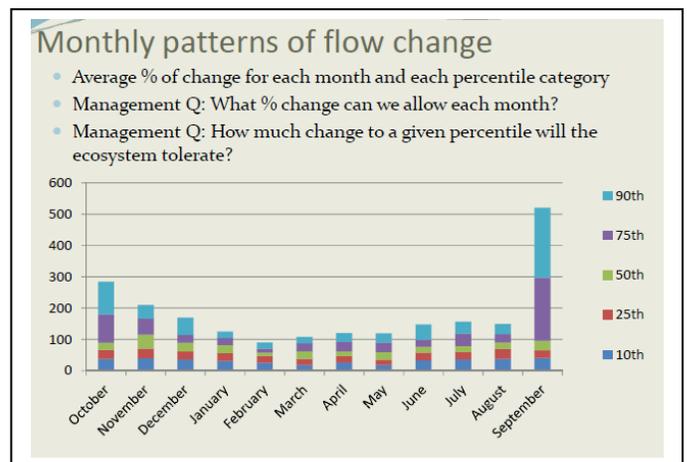


Can look at it by month- Monthly patterns of flow change slide- see Sept one of most stressed months. Can see variability across the year and within each percentile...how much contemporary change have we had from a temporal aspect. In terms of management questions: **What % change can we allow each month? How much change to a given percentile will the ecosystem tolerate?**

Both regard different components of the river system. An important thing to look at are potential controls (statistical) of each pattern, I'd like to do an ordinal review or cluster analysis to see if there are patterns associated with different controls- looking at dams, water withdrawals, land use, and potential physiographic controls (drainage area, possibly stream gradient)

Our end goal : Decision Support with this 5 component criteria to determine environmental flows:

- 1) **WHO:** Biotic analysis, choosing specific species, guild or process (like a channel maintenance process)



- 2) **WHAT:** Determine what is the purpose for protecting the flows- ex a migration cue for spawning, channel maintenance flow
- 3) **WHEN:** Looking at time of year that flow may be most important (migration for spawning may be March, April, May- seasonal)
- 4) **WHERE:** Looking at locations where particular species and needs would occur relative to ecoregions and if it is connected to a certain size drainage area
- 5) **HOW:** What our analysis tells us about how much change we've seen with seasonal time period relevant to species, then setting some kind of **protective flow criteria to prevent further change to that percentile**. Determine what that ecological flow would be. Another component- you could have an asterisks or other parameter, for example if looking at endangered species as another component of ecological relevance.

Following is an **example** of how to determine ecological flow protection using these 5 components:

1. Who: species or guild
Riffle and riffle-run
2. What: biological or physical process
Spawning
3. When: timing, seasonality
March - May
4. Where: ecoregion and drainage basin area
Blue Ridge > 50 mi², Piedmont > 50 mi², Coastal Plain < 1,000 mi²
5. How: % change tolerance or % allowable extraction using percentiles
Allow 10% of median flow to be withdrawn until flows reach 25th percentile

A lot of this information is extracted back out from the literature review. TNC goal for project- work through these 5 components looking at all the guilds.)Then look at species of concern. TNC is developing flow recommendations to feed into the TNC resilience analysis. If there's anything that we're doing that can help EFSAB, we're more than happy to provide that for this group's use .

Timeline- my project will be completed June/July.

Facilitator: Kim had planned a longer presentation, but limited presentations to brief updates in order to focus on planning future steps. As we move into recommendations, if you want her to come back for an update, she can do this. Questions of clarification?

Q: Your recommendations for this group is in June?

R: This is not necessarily recommendations for this group but fulfilling resilience requirements for TNC, but if this can help, there is parallel and overlap.

C: It seems like it might be informative if you take CVs and overlay that with population change over same time period as well for humans and animals, would be a curious comparison.

R: I will relay it with people population change, but harder to get at biological aspect. I showed you change but not + or -, the next analysis will show simply whether change is + or -, I didn't have time yet.

C (Rebecca, TNC): TNC Resilience Analysis will also overlay land use change... flow patterns if buffered or not buffered (*some is inaudible*)...timeline for that is end of year. That also will add a lot of data layers.

R: One of our goals are to look at current contemporary conditions for biology and for hydrology, what are present threats, determine areas under most risk, determine protective flow measures based on that criteria. Example of a recommendation given, allowing a % of the median to be extracted until it reaches what would be the 25th percentile. I think at no case should we set a 10th percentile, those flows are much too low and you'd

lose a lot of the natural variability of system. Goal would be to look at calendar and set variable guidelines /goals for each month based on specific ecological requirements for the guild, then stratify across state by ecoregions and drainage basin area.

Q: The take-home for me, it seems like high flows seemed to be higher in recent years, low flows tend lower in recent years, possibly due to greater impervious surface, more people, and agriculture use. Is that a reasonable take home message?

R: Yes, I agree completely. Though *the change is highly variable across state, and variable across month*, why it's important to have specific flow recommendations for each month. No one flow that would work across the year. Changes also vary across ecoregions...changes may be consistent in smaller basins- some of the smaller basins may need more protective measures. Might have slightly looser goals for larger basins. Kind of important to stratify that and justify why. I tried to look at contemporary time period and see which areas are at risk, so that focus could be on that to set thresholds.

C: We have to be careful to determine cause and effect of change of flows of highs and lows without looking in detail at (other variables) you mentioned tropical storms, etc...

R: Definitely a combination of natural climactic variability, its hard to tease some of that out. Cape Fear also has the influence of dam releases. In Tar Pam we don't have those large structures and that's one of the ones where we see the greatest change in the extremes- in that one we can eliminate large scale dam regulation as a factor. Lower Roanoke has dam impacts. Tar-Pam we can assume changes are from climate and land use change. An important thing is the spread in Aug/Sept is changes in irrigation schedule.

Q; Agricultural irrigation? (yes) That's not same as municipal, their peak demand is different.

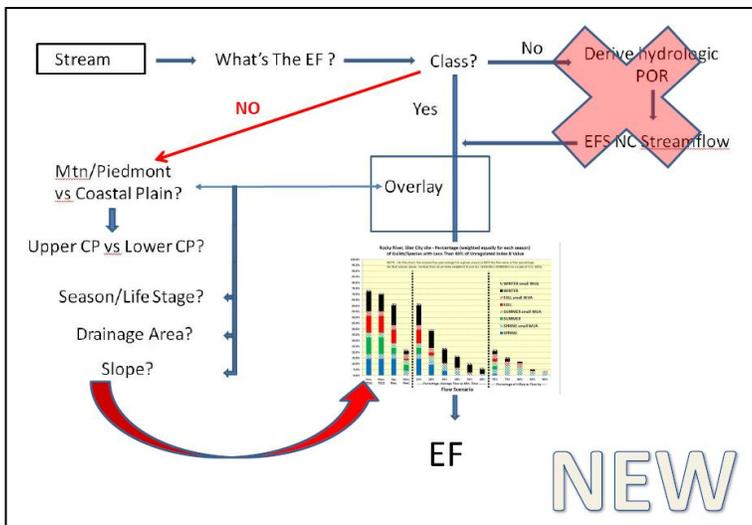
C: Regarding caution of cause/effect, we also have big diff in evapo-transporation, infiltration rates over the year.

R: Yes, also impacted by natural and production food growing seasons.

C: Nice job. Great work.

VIII. Developing a Path Forward

Presenter: Fred Tarver , NC DWR



We think its important to clarify how EFSAB's recommendations will be applied.

First about how they **will not be applied**: based on the statute G.S. 143-355(o)(8) Construction of subsection. " Nothing in this subsection shall be construed to vary any existing, or impose any additional regulatory requirements, related to water quality or water resources." **Meaning this is not policy this is planning.**

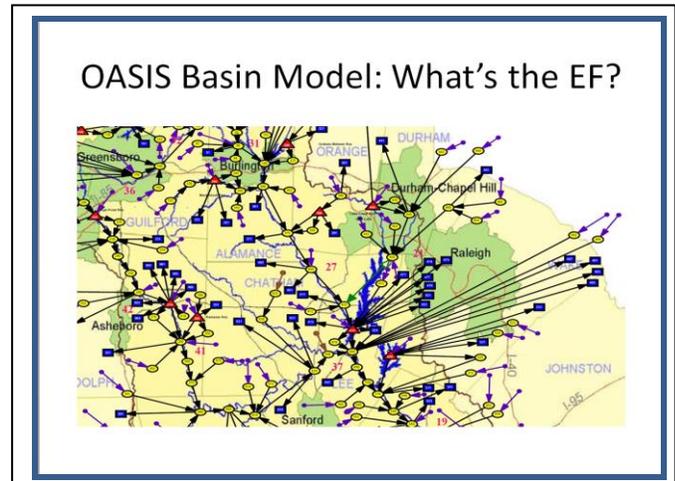
Next, how they **will be applied**. You might have recalled this dynamic schematic, has been slightly modified since last time (see red X),

facilitators asked us to put on paper how this affects our lives in DWR. I created a flow chart of how we'd use EFSAB recommendations in modeling.

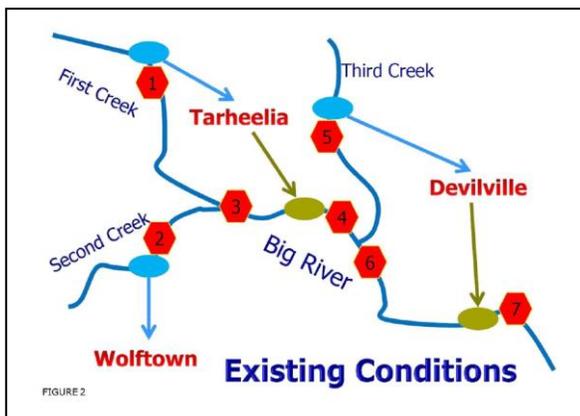
Back then we were looking at EFS classification, but wheels fell off that effort. Back then we had the classes based on hydrologic characteristics. Then you move down classification talked about adding another component, perhaps overlays based on something- is it physiographic region, season, mountain, piedmont, coastal plain, then based on overlay + class we'd come up with ecological flow.

New approach slide- newer approach- red x eliminates old EFS approach since it fell apart.

We all hope we have some sort of classification/characterization process, some kind of overlay similar to SLCC, based on all those components on left of slide and maybe more. If we don't have classification, if it doesn't come to fruition, maybe a fallback may be a physiographic region overlay. Hopefully we'll have an overlay with a geographic component, then rather than an ecological flow, a process to come up with Eflow. Whether it's a flow statistic, an average, a % flow by, whatever method that will be take within DWR and based on equations will come up with eflow to plug into the model. Whether it's a particular number like a value statistic or percent. This is my perspective based on our new approach.



We'll take the ecological flow, and put into node wherever you determine to put in watershed, and plug into the model (see the above slide of the model, and the below hypothetical ACC watershed slide with the red nodes that potential e-flows).



Further clarification of how recommendation will be applied, I'll refer back to statute:

G.S. 143-355(o)(3)(b) – “The model shall specifically be designed to predict the places, times, frequencies, and intervals at which any of the following may occur:

1. Yield may be inadequate to meet all needs.
2. Yield may be inadequate to meet all essential water uses.
3. Ecological flow may be adversely affected.”

That is how “essential uses” are defined in the statute.

Those are what we're trying to achieve when applying eflow

recommendations into the model, not only to address the yields, but the ecological flows.

Who is the audience for EFSAB's work?

Environmental Management Commission: Law requires submittal of model for public comment and approval by EMC, including significant modifications to approved models. If we're tweaking or refining models to a level of significance- have to resubmit to EMC for comment period and approval again.

Environmental Review Commission: Law requires annual report on development of hydrologic models to ERC. This is ongoing since we're continually developing models

The Public: Opportunity to comment through EMC comment periods, and have access to models on DWR website. People can access and do evaluations of models on their own to determine if they are in agreement or not.

Q: Are these commissions about to be restructured?

C: Not the ERC, that body is composed from the legislature.

C: Water system planners: municipalities & utilities, perhaps agriculture. They want to understand patterns of flow over time for a 50 year horizon. The Division of Water Resources & other agencies may be interested in using models such as for water quality and quantity, and natural heritage.

How will recommendations and model benefit major water users?

- Long-range planners seek some level of certainty in the availability of the resource; the model contributes to that certainty- between a 20-50 year horizon
- Model provides water users a window of opportunity to plan for potentially new sources of water, future modifications to infrastructure, and new and innovative conservation efforts.
- Models can be used to do “what-if” scenarios

That’s it. Is that clear? Questions regarding what Fred presented

Q: I wonder if you’re missing a slide about audience. Who will we hear from? What are the pitfalls? If this process affects the bottom line of industry, it will be challenged.

R: What Tom said before about being able to withstand scientific scrutiny, we can have a debate about that if that should be our standard. If we do that, it should stand up to a certain amount of criticism.

R: You can expect comments from any segment of the population. Also, all the members of this board represented certain segment of stakeholders; we hope that they’re addressing that segment of interests. There is no guarantee...there will always be people outside the process who may have issues with the process but we try to do the best possible work based on what the charge is. The whole focus is strictly on planning not policy. There is a lot of speculating but we should be focused on what we’re charged to do- planning.

C: Clarification; we are not representing constituencies in this process; we’re representing the science. Constituencies have and can contribute to the process. I represent environmental organizations’ science, I do not represent any environmental organizations’ agenda.

Facilitator: You all did have this conversation early on in the development of the Charter that is a science advisory board, not a stakeholder group.

Q: I have a question about yield (the 3 bullets)- meeting all needs, essential uses, and eco flows. “All needs” includes e-flows, right, and essential does not?

R: when we talk about yield we talk in terms of water supply. I assume that’s the intent. It’s so ambiguous I hate to assume. In water supply I think of water supply, but when you talk about essential water use it is defined in the statute so there is specific language, though it covers the whole gambit.

C: First one, when I think about how eflows will be plugged in, it helps me to try understand what the threshold is, that’s by its self in 3. Not plugged into all needs.

DWR: Session Law 2010-143, SECTION 1. G.S. 143-350 Definitions (3) "Essential water use" means the use of water necessary for firefighting, health, and safety; water needed to sustain human and animal life; and water

necessary to satisfy federal, State, and local laws for the protection of public health, safety, welfare, the environment, and natural resources; and a minimum amount of water necessary to maintain support and sustain the economy of the State, region, or area". It's a pretty broad category.

C: That helps me understand this is nothing we can hang our hat on – it's broad and nebulous.

Facilitator: If we need to address those concerns may need to do it at next meeting.

IX. Introduction to the EFSAB Assessment

Presenter: **Mary Lou Addor, NC State University**

A brief assessment was conducted with the EFSAB during January, 2013. In all, 23 members and alternates of the EFSAB (out of 26 possible) participated in the assessment via phone interviews including former members. The data gathered resulted in valuable responses that were distilled into a summary. The purpose of the assessment was to help clarify issues before the EFSAB and to determine how to increase the likelihood that the EFSAB can generate recommendations that will advise the NC DWR on how to characterize the natural ecology and identify flow requirements. The assessment was also designed to assist the project team (DWR staff and the facilitators) with recommendations for structuring the 2013 process.

Comments by the EFSAB members in response to the questions were compiled, described, and summarized in the assessment. The categories are intended to reflect the various comments heard during the interviews, though some comments were paraphrased to reduce repetition and improve clarity for the reader. If similar comments were made by multiple interviewees, the level of frequency was noted in parentheses following the comment. This is a descriptive overview of the EFSAB's recommendations for how to proceed in 2013; it is not a quantitative analysis of the results.

The EFSAB is charged with advising DENR on approaches to characterize the aquatic ecology of different river basins and to help identify the flows necessary to maintain ecological integrity. When individual members were asked if they would be able to:

Question 1a. provide recommendations to DWR in 2013 about approaches that characterize the aquatic ecology of different river basins- they responded with:

- 5 answered "yes" or "I think so"
- 5 answered "yes" with qualifications
- 3 answered "yes" but "not sure for all river basins" or "not sure for coastal plain"
- 4 answered "possibly", or "hope so", or "should be able to do so"
- 1 did not answer the question, but provided suggestions for getting there.
- 5 answered "unlikely", "not sure", "some concerns can't"

In addition members identified several approaches to help characterize the aquatic ecology of different river basins:

- | | |
|--|--|
| m. Determine What is Good Enough | p. Levels of Alteration Approach |
| n. Distinguish Level of Detail Required | q. Levels of Classification Approach |
| o. Characterize the Ecology by what Cuffney has done for macroinvertebrates | r. Basin Level Approach (Scale of Approach) |
| | s. Characterize by geomorphology |

- t. Characterize by Seasonal Approach
- u. Additional Scientific Information Required
- v. Clearly defined biological component/process for describing the ecology
- w. Decision point on Scale and Scope
- x. Firm up a guiding principle of classification of ecology (temperature, flashy/riffle/pool, etc.)

Question 1b. provide recommendations to DWR in 2013 that help identify the flows necessary to maintain ecological integrity, they responded with:

- 10 responded “Yes”
- 4 said “Yes”, it “depends on”
- 8 who said “Yes” with “caveats”:
 - But not in the coastal plain (2)
 - But not full consensus since not everyone is comfortable with a screening tool
 - Guidelines for determining the flows, (big picture) but not the flows themselves (3)
 - If generalizations on ecological variations can be accepted by members
 - Wrestle with flows for specific reaches
 - Focus converging from scattershot to more organized approach
 - Need to incorporate the diverse views to achieve good decisions
 - Identifying flows will be harder than characterizing ecology
 - Identifying ecology will be easier than identifying flows
- 1 said “Not Sure”

In addition members identified several approaches to help identify the flow necessary to maintain ecological integrity:

- e) Determine specific items
- f) Decide on specific items such as family of strategies and strategies not to use, plus how to treat coastal area.
- g) Gather additional data
- h) Provide methods, not specific flow numbers, characterize ecology broadly.
- i. Scope of decision making is broad and general (keep recommendations at large scale)
- j. Assumptions behind EFSAB Recommendations
- k. Hone in on Planning Component
- l. Value and include a wide range of scientific opinions

Questions 2 & 3 addressed recommendations for meeting procedures and/or structures that would aid the process of providing recommendations. This section also included general comments, suggestions, or concerns. The major categories that resulted were:

- i. Reactions to Past Two Years
- j. Develop a visible Project Timeline
- k. Establish Process Design to Accomplish 2013 Goals
- l. EFSAB Report: Outline, Process for Compiling Data and Writing, Other Requirements
- m. General Meeting Design
- n. Recommendations for Process
- o. Recommendations to the Project Team (DWR and Facilitators)
- p. Post-EFSAB process concerns and suggestions (2014 and beyond)

Themes Heard from Multiple Interviewees

1. Good educational framework has advanced scientific discussion and process around e-flows (met a portion of the EFSAB charge as a result)
2. EFSAB is a fantastic group –well intentioned and thoughtful; enjoyable to work with. People have been diligent; everyone has put their all in it and treated it with the seriousness needed. Project team (DWR and facilitators) has done a good job with a very difficult task.
3. Identify 2013 structure for providing recommendations: timeline, milestones, deliverables, and who will complete these tasks.
4. Utilize small group work within the large group meetings much more frequently and working groups between the meetings.
5. Provide scientific recommendations that can be implemented with practicality for the benefit of NC DWR and local planning organizations
6. In 2013, focus on convergent thinking, less on advancing the science. Hence move forward with what is known today; add additional data layers later when known.
7. Work to reach understanding among members and constituents about the purpose and use of e-flows, and develop better language for communicating it.
8. The work that the EFSAB has done has better positioned members to characterize the ecology.
9. NC DWR should provide guidance and direction on level of detail needed and options for moving forward (trial balloons).
10. Don't let perfect be the enemy of good
11. If the process stops, is shut down, or agreement in recommendations cannot be achieved - it has been worth the effort to advance the science and capture this information for future work, particularly with this group of people.

Areas of Concern

1. Members and constituents have different perceptions of the potential implications of Eflows
2. Revisiting Information that has been discussed happens frequently (though sometimes a refresher is great)
3. Capacity of NC DWR to provide project leadership given loss of critical staff
4. Some groups (outside the EFSAB), may not accept the science if they do not support the results (in spite of EFSAB being a mix of scientific perspectives to the process)
5. If the science is less than the best, a recommendation that potentially errs on the protective side may be needed for now.
6. The legislation itself does not make clear that the process is for planning purposes
7. How to manage for the best science and concerns about future water use (is it water use or knowing how to plan for water use?)
8. How to manage for implications of e-flows: if it's for planning purposes, are there benefits to end users and natural ecology (rather than solely focusing on the downsides).
9. Calling it e-flows rather than a planning tool for e-flows or a planning threshold causes problems; gets into implications.
10. This process requires an intense body of knowledge; some are more knowledgeable than others as they live and breathe the science – others are figuring out how best to contribute to the process and have to become re-immersed in the discussions each time we meet. Since EFSAB members are in different stages of knowledge and understanding (and there is limited time to review the materials), a level of patience is required in working with and when testing assumptions with each other.

Each member of the EFSAB was asked to read the meeting summary in its entirety. Members were asked to determine whether their comments were accurately reflected in the summary and to listen to the suggestions and recommendations being posed by other members in preparation for the March 19, 2013 meeting.

X. Introduction to the Annotated Meeting Information and Index of Meetings -

Presenter: **Christy Perrin, NC State University**

The facilitation team developed an excel file spreadsheet that summarized the meetings of the EFSAB. Since Nov 2010, the EFSAB has participated in 16 meetings. The Annotated Meeting Information captures 16 meetings of the EFSAB since November 2010.

The categories of the summary include:

- date of the meeting
- whether a recording is available
- purpose of the meeting
- pre- meeting materials titles and authors
- presentations and presenters
- key definitions and acronyms
- major discussion items
- major issues, questions, and concerns
- decisions/recommendations: meeting process
- decisions/recommendations: new presenters or presentations
- decisions/recommendations: methods of studies, convergence and alignment on new methods or procedures
- decisions/recommendations: elements of the planning tool for E-Flows
- decisions/recommendations: consensus principles
- unresolved issues: current and prior meetings
- 2013 Report to ERC: Subject Matter
- issues for Eflows 2014 and Beyond
- Action items and responsible person

The Annotated meeting information will be updated with each meeting summary and distributed to the EFSAB.

XI. Assumptions About Ecological Flows as Defined by DWR

Presenter: **Nancy Sharpless, NC State University**

These facilitation team culled assumptions about ecological flows from the Ecological Flows Science Advisory Board (EFSAB) meeting summaries. These assumptions reflect guidance and information provided by the Division of Water Resources (DWR) to the EFSAB. The purpose of this activity was to make explicit what had been in some cases, implicit understanding about the process.

Two groups reviewed the assumptions list and offered revisions (for the entire list of assumptions with revisions inserted, reference Appendix A):

Group 1: Tom, Ian, Peter, Jamie, Fred, Sarah, Jay, Hugh, Sam, with Kimberly and Don

1. Nov 8, 2010:
For Planning purposes – recommend strike ? statement how to quantify the instream component (4th bullet)
Make clear 2 statements regarding the site specific studies
Ecological integrity in Eflows focuses....CLARIFICATION: that ecological integrity is defined in legislation water. Water quality component is important.
2. May 17, 2011:
Concern over wording regarding endangered species -2nd bullet. Do not know if ESA are being protected by guild approach. WRC guilds only include fish and benthos or habitats. Some are included but obviously are small component. Are there exceptions? Do not let one fall through cracks.
Consider TNC Work
Strike 3rd sentence
3. Nov 15, 2011
Concern over last bullet regarding presumptive standard of 7Q10. Is it lowest extreme? Consider striking as it may no longer be an accurate statement
4. Nov 27, 2012
Strike last 3 bullets- first bullet is sufficient

Group 2: Bill, David, Bob, Becca, Vann, Mark, Chris, & Judy with Jim and Ed

1. Distinguish between environmental flow and ecological flow - legislative definition
2. Nov 8,2010: for statement of No Flow #- revised to say, “Charge states to advise on methods and approaches and flow requirements – the approaches MAY be numerical but not site specific.”
3. March 5, 2011: EFSAB use to consider that there was limited data for small streams but there has been a shift in understanding with the introduction of WaterFALL.
4. May 17, 2011: (top of page 2): reservoirs (regulated waters) have an established “operating flow requirements”. Rivers affected by big operations will maintain existing structures.
5. June 21, 2011: Also deals with reservoirs. The EFSAB is not going to address the downstream (affected water component) but can raise the issues. Will not address the factors though these factors have implications for ecological integrity. Can recommend how to use these factors (climate change, land use,...) in modeling but it is not the task of the EFSAB to recommend how to deal with this components. South Carolina study – where in the affected reach is the point downstream that ecological flows should be introduced.
6. Nov 15, 2011(pg 3.). DWR may test presumptive standard. Revise to say, “There is value in testing a literature based approach (replace presumptive standard with literature based approach) in Oasis to demonstrate where the red flags show up (Tar, Lumber).
7. June 21, 2012: (2nd sentence,1bullet): “water withdrawal very seldom has the capability to ...eflows”

XII. Issues to be Resolved in Moving Forward

Presenter: **Nancy Sharpless, NC State University**

The same two break out groups met to review and discuss the proposed list of issues that the facilitation team believes remain to be resolved by the EFSAB.

Group 1: Tom, Ian, Peter, Jamie, Fred, Sarah, Jay, Hugh, Sam, with Kimberly and Don

Group 2: Bill, David, Bob, Becca, Vann, Mark, Chris, & Judy with Jim and Ed

Each group was asked to identify:

1. What was missing from the list as proposed
2. Of the items listed, had any issue been resolved
3. Of the items listed including any issues missing, what is the order for discussing these issues using a timeline format for the remaining meetings that are scheduled?

Issues Identified as Missing:	
Group 1	Group 2
IIIA. Request presentation of the SALCC effort (request to remove SALCC, others interested in hearing about the SALCC efforts)	Hydrologic modeling in the Coastal Areas
Literature needed to summarize a bibliography	Adequate discussion on the interaction between Water Quantity and Quality, coastal salinity and elsewhere, biological oxygen, DOD, thermal,...

Issues Identified as Resolved:	
Group 1	Group 2
<ul style="list-style-type: none"> ▪ IIIA.4—biofidelity off the table—now it is environmental attributes and biology IV—PHABSIM is data source...not trying to get rid of it for site specific work	IA1: These ecological flows are being developed for planning purposes not policy. Charge states to advise on methods and approaches and flow requirements and the approaches MAY be numerical but not site specific.
<ul style="list-style-type: none"> ▪ IV.B No more validation of WaterFALL by EFSAB. DWR may require more validation for their purposes 	2a. WaterFALL will not suffice for generating flows for coastal plains.

IV—predict it will be threshold by variable - work with RTI and TNC to use those products	
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MARCH 2013	
Group 1	Group 2
Presentation on SALCC efforts	Review/Post Charge each meeting
BEC Update	Species-ESA discussion with Mark and Chris: focus on discussion of a good fit (any habitat requirements for ESA and how that fits into BEC will be discussed with Jennifer P/RTI)
Coastal Plain—propose a consensus principle to develop and test <ul style="list-style-type: none"> ▪ Speak with Bob Christian about writing one ▪ Write about why hydrologic approach doesn't work for coastal plain ▪ Don't spend significant time on it. 	DWR is prioritizing completion of hydrologic basin models based on withdrawal pressure (projected increases in withdrawals) so development of Eflows Tools is hopefully consistently with that (i.e., Eflow approaches for basins and/or streams classes with higher withdrawal pressures should be developed first.
Plan B for moving forward?	Tackle literature needs
Mountain model test output of real gages (Sam, Tom)	Focus on Issue III: Characterize the Ecology Measures of Ecological Integrity and Define Thresholds – how much change is too much? (Information from Catawba)

April 2013	
Group 1	Group 2
BEC Update	Review/Post Charge each meeting
TNC Update (completed)?	Continuation of Species-ESA discussion as needed with Mark and Chris: focus on discussion of a good fit
Report out of endangered species subgroup	Focus on IV: Approaches to Recommending Eflows <ul style="list-style-type: none"> ▪ Review other states (South Carolina) ▪ Water Wiki
Summary of results of 3 families of habitat scenarios for a handful of sites Evaluate specific scenarios (or evaluate Jim's habitat scenarios), perhaps while BEC under way as a chapter	Tackle Literature Gaps on Coastal Areas APNEP , TNC, & Savannah
	Continued discussion on Characterizing the

	Ecology, Measures of Ecological Integrity and Define Thresholds – how much change is too much? (Information from Catawba)
May 2013	
Group 1	Group 2
BEC Update	Review/Post Charge each meeting
	Coastal Hydrologic Modeling
	Continued Discussion on Approaches to Recommending Eflows <ul style="list-style-type: none"> ▪ Review other states (South Carolina) ▪ Water Wiki ▪ Classification Options
	Tackle Literature Gaps
	Continued discussion on Characterizing the Ecology Measures of Ecological Integrity and Define Thresholds – how much change is too much? (Information from Catawba)

June 2013	
Group 1	Group 2
BEC Update	Review/Post Charge each meeting
	Continued discussion on Coastal Hydrologic Modeling - How to treat coastal areas
	Adequate discussion on the interaction between Water Quantity and Quality,, coastal salinity and elsewhere, biological oxygen, DOD, thermal
	Tackle Literature Gaps
	Continued Discussion on Approaches to Recommending Eflows <ul style="list-style-type: none"> ▪ Classification Options –decide on options

Sept 2013	
Group 1	Group 2- make Sept a 2 day meeting schedule now
BEC Update	BEC- draft report ready to present to EFSAB

XIII. DWR's Proposed Report Format & Approaches for Completion

Presenter: **Christy Perrin, NC State University**

The facilitators introduced a template for the final report of the EFSAB, proposed by DWR with revisions suggested by the facilitation team (Attachment A).

The facilitator reviewed the document noted the major sections of the report template as proposed by DWR:

- The Executive Summary would be written last;
- Items V. and VI. are not ready to be written;
- Item VII. is the literature cited,
- The EFSAB's bibliography, which is a little different from IV., which is a review of supporting information.
- Item IV. is more of a summary of what the EFSAB has heard and what that means.
- Several proposed appendices are included.

Fred Tarver was asked to clarify who the audience was for the report. He responded:

- A wide range of people who would be interested.
- Anyone who picked up the report and had never been to a meeting before should be able to go through it and get a firm grip on the process.
- The EFSAB could have a technical guidance document, a condensed version of recommendations, in the back of appendices.
- The report should meet the need of all the record books, people in our audience, whether it's the ERC, the EMC, the public or utilities, or water systems. It needs to be pretty thorough.

Questions and Comments included:

Q: Does the legislation require a report? We are advising. So it could be a memo? With a big appendix?

C: Item number VII. is Literature Cited. Recommend changing to an annotated bibliography of the literature review of this report. My guess is that some of it won't get cited in the main body of the report and we should include an annotated bibliography of the literature that was distributed to and reviewed by this Board.

C: On page 1, item IV.B.3 and C, about a fourth of the way through, about a fifth of the way up from the bottom of the page, it says "Other State Efforts." I don't recall having much conversation about other state efforts. We had a few summary-level presentations. How will the General Assembly receive information about other state efforts; will it inform them? Irritate them? If we want a comprehensive look at other state efforts, Amy Pickle, a member of this Board, is doing a survey of all eastern water law states, which is 31 states (all of the states east of the Mississippi and all the states that border on the Mississippi, those that actually touch the river) and their ecological flow work. It's a legalistic survey that puts out laws, regulations, policies, and practices, but doesn't look at science. Perhaps this could be an appendix to the report.

R: If Amy can present the report to us, that would be appropriate. If we've never heard it, I don't know that we want to put it in the appendix. We need to see it.

C: I would say with regards to the other states' efforts piece, a lot of those were assigned readings that Jim suggested when we started earlier. So if we're going with the bibliography approach, I think that would capture some of that, versus spending time on the final report.

R: I agree.

C: I wonder if maybe part of the problem here is placing the work that we end up with in context of other states that have already gone through this. South Carolina came up with 20-30-40 mean annual flow. That was their

recommendation. That's in their statute. How does ours compare to that versus Michigan or Connecticut. Not that we get into all the details, just say, you know, here are what other folks have done and you have a brief understanding of basic things in that context.

Q: Don, didn't you do a review of neighboring states, their in-stream flow policy?

R: Just touched on it.

Facilitator: I'm going to suggest that we keep it on the table, at least to investigate how to cover this. Let's not decide tonight. Any additions to the outline that you've thought of?

C: Throughout the outline, it says the environmental flows, instead of ecological flows. Is that intentional?

R: It was not intentional but an error and should be stated as ecological flows.

C: The way the support information is laid out, you touch on basic state efforts in the published articles and then you touch on basic state efforts in presentations. We want to have all the information on that particular topic, whether it's a presentation or a published article, together.

Facilitator: So have it by background topics, rather than whether it's an article or presentation?

Facilitator: I want to tell you how we thought about dividing this up for writing. We were going to ask for volunteers. Our proposal was that DWR and the facilitation team could write the Introduction (section III). We thought that writing groups from the EFSAB could take on the remaining sections with the exception of the appendices. Section IV (Supporting Information Review) may be ready to be written and thus could serve as an interim report if one were needed. Those who have interest in that topic and could provide a draft in several months, could tackle this section.

The remaining sections, V and VI, would come later. For recommendations (Section VI), we thought that the facilitators could provide some kind of a framework work to help with that, but then let a small group write that as well. Does that make sense to everyone?

C: Half of the report could be written sooner than later; and writing this section may assist with decision making since it would compose the Literature Review. The actual literature for this section has probably been provided to you during the duration of the meetings.

C: I'm in the process of writing the literature review document for TNC; it's looking at a lot of biological analysis done in the southeast relevant to biology.

R: We may need to use what has been distributed among the Board already.

Facilitator: The report will be completed in draft stages. The idea is that there would be working teams spending time on these sections but a core group would provide oversight. Someone needs to take a global look at the whole thing and make sure everything flows and fits together.

C: Recommendations: 1). The people who made the presentations should be asked to summarize them. Can go back through the minutes and contact the presenters to provide the summaries and include those in the report. 2). The question of who should write chunks of this may be premature. Let's agree to an outline first.

C: Another suggestion regarding presentations – formulate small groups by topic based on the people who gave those presentations and have them draft a larger summary rather than simply providing a summary of their presentations (which are already in the meeting summaries).

Facilitator: We are happy for you to consider the report between now and March and think about what part

would you want to write and when? We believe the EFSAB needs to determine a timeline for the report.

XIV. Summary of Meeting & Information on Next Meeting

Presenter: **Bob Christian, Eastern Carolina University**

First of all, one thing that impressed me today is how much work is being done for the state by NGO's and non-state organizations. That must be acknowledged. The first part of the day dealt with various aspects of the hydrological modeling, and the good news is that for the biological and environmental classification, it looks like funding is in place for both the fish and the invertebrates and for [completion at] the end of the summer.

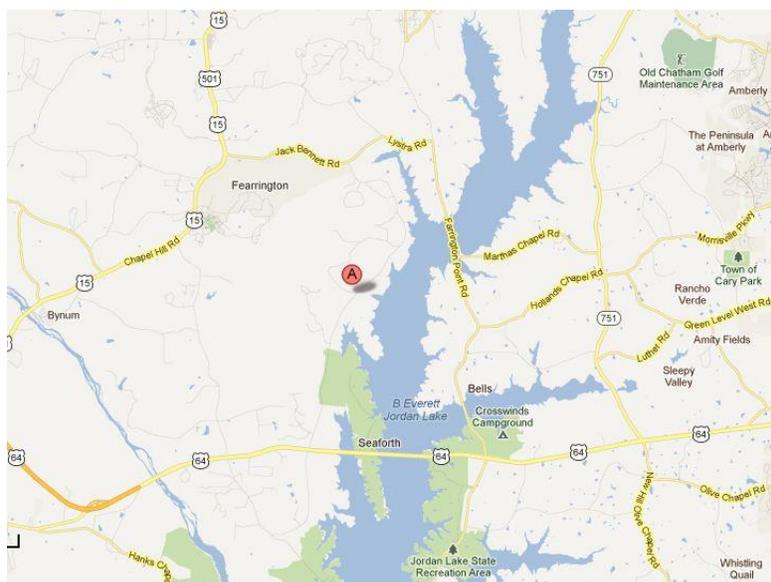
The bottom line for me on the comparison of OASIS/WaterFALL and gauging stations is that it works sometimes, but not others. I thought Kim did a fantastic job of presenting The Nature Conservancy's project. I think there's very interesting and useful information coming out of that. For the remainder of the afternoon, we participated in a series of exercise to get us all on the same page and moving forward.

The facilitators thanked everyone and the meeting ended.

Next EFSAB Meeting (Agenda Topics- TBA):

The next meeting of the EFSAB is scheduled for **March 19, 2013** at the Stan Adams Educational Center from 9:15am until 4:15pm. Please remember to bring lunch and refreshments with you. Coffee will be available on site and soft drinks are (\$1). **Webinar:** If you cannot attend the meeting in person but would like to join us via the webinar, you can watch the presentations and listen to the live streaming audio of the meeting by accessing the link and typing your name in the space labeled "guest": <https://denr.ncgovconnect.com/sab/>

Meeting Location & Directions: The meeting location is the Stanford M. Adams Training Facility at Jordan Lake Educational State Forest. Directions are: 2832 Big Woods Road, Chapel Hill, NC 27517. From Rt 64 and Big Woods Road, it will be the first Forest Service sign on the right. Pass the office building and continue on through the gate to the education center. For Map link: <http://go.ncsu.edu/stanadams>



Appendix A: Exploring Assumptions Defined by DWR

Determining Ecological Flows in North Carolina: Assumptions of Eflows (as Defined by DWR)

These statements were culled by the facilitation team from Ecological Flows Science Advisory Board (EFSAB) meeting summaries. They reflect guidance and information provided by the Division of Water Resources (DWR) to the EFSAB.

November 8, 2010

EFSAB – What It Is Not

- Not the final decision-maker on this issue.
- Will advise on methods and/or approaches – not specific flow numbers.
- Not developing a method to replace sites specific studies needed for a specific environmental assessment (EA)/environmental impact statement (EIS) or permit review.
 - a. Regarding no flow #: rewrite to state - Charge states to advise on methods and approaches and flow requirements – the approaches MAY be numerical but not site specific.

River Basin Approach to Planning

- A one-size-fits-all approach to ecological flows (EFlows) is not appropriate given the diversity of rivers and streams in North Carolina. Differences in hydrology result in different habitats, which result in different ecological communities with different flow needs.
- The approach and methodology will be used by DWR staff for **planning** to help users meet anticipated water needs in the long-term future (20-50 years) & address concerns at a watershed level that includes cumulative effects.
- Site and project-specific evaluations require time and money thus field studies at every location are not practical, **hence there is a need for ecological flows planning; this is the purpose behind the statue (added). Make clear 2 statements regarding the site specific studies**
- For planning purposes the task is to evaluate in-stream and off-stream water availability now and in the future. How to quantify the in-stream component? **For Planning purposes – recommend strike statement how to quantify the instream component (4th bullet)**
- Off-stream component of water resources management is already quantified in the model using existing water-use data and projected increases.
- DWR anticipates updating the planning model every 10 years given available resources.
- Ecological integrity in EFlows focuses on in-stream aquatic habitat as it's affected by flow, not the quality ramifications of that flow change that is part of NC Division of Water Quality's assimilative capacity modeling. **Ecological integrity in Eflows focuses....CLARIFICATION: that ecological integrity is defined in legislation water. Water quality component is important**
- EFlows can be added to the river basin models to complete as scheduled.

I. January 18, 2011

- Hydrologic model calibration and validation has concentrated on normal and low-flow periods, when water supplies are stressed. To ensure a model's scale works for the scenario being evaluated, DWR will need to review the validation process if the approach for determining EFlows includes one or more high-flow statistics.

II. March 5, 2011

- There is limited data (stream flow gages, PHABSIM habitat studies) for small streams (headwaters); not much water is taken for water supply purposes at these points. **Since the March 5, 2011 meeting, there has been a shift in understanding with the introduction of WaterFALL.**

III. May 17, 2011

- Many of the large rivers in North Carolina have their hydrology significantly altered by large dams and reservoirs. The EFSAB will need to consider what the baseline condition is for determining EFlows. It is likely that locations downstream of large reservoirs will use the existing conditions as the baseline. The EFlows legislation is not aimed at addressing the operation and management of existing large reservoirs. **May 17 (top of page 2): reservoirs (regulated waters) have an established “operating flow requirements”. Rivers affected by big operations will maintain existing structures.**

- Endangered species are very important for a particular river, and are important for individual project reviews and permit decisions. However, for basin-wide and state-wide planning purposes, their scattered and variable occurrence makes endangered species less appropriate to include in the guilds being evaluated to determine EFlows. Consideration should be given to whether the species’ requirements would be addressed by selected guilds. **Concern over wording regarding endangered species -2nd bullet**

- a. Do not know if ESA are being protected by guild approach. WRC guilds only include fish and benthos or habitats. Some are included but obviously are small component. Are there exceptions? Do not let one fall through cracks.**
- b. TNC Work?**
- c. Strike 3rd sentence Consideration should be given to whether the species’ requirements would be addressed by selected guilds**

IV. June 21, 2011

- Reservoirs can alter high-flow regimes. Presently **water withdrawal very seldom** has the capability to impact high flows; it is this large storage in reservoirs that re-regulates downstream hydrology. We can acknowledge the importance of high flows to stream ecology, but not focus on them to determine flows for ecological integrity in the context of water supply planning – focusing instead on run-of-river withdrawals and low-flow scenarios. **June 21 – 2nd sentence,, 1bullet: water withdrawal very seldom have the capability to ...eflows**

- Reservoirs are more suited to case-specific permitting as opposed to the planning process the EFSAB is trying to develop. (also June 21 deals with reservoirs) – the EFSAB is not going to address the downstream(affected water component) but can raise the issues. Will not address the factors though these factors have implications for ecological integrity. Can recommend how to use these factors (climate change, land use,...) in modeling but it is not the task of the EFSAB to recommend how to deal with this components. South Carolina study – where in the affected reach is the point downstream that ecological flows should be introduced.

- Land-use change. It can have a significant impact but it is not a part of the legislative mandate for determining EFlows. Alteration of hydrology associated with significant changes in land use is captured in the flow record.
- Acknowledge high flows but focus on the impacts of water supply and water withdrawals on EFlows.
- Acknowledge land use but focus on the impacts of water supply and water withdrawals on EFlows.

V. August 16, 2011 - None noted

VI. September 20, 2011

- DWR is prioritizing completion of hydrologic basin models based on withdrawal pressure (projected increases in withdrawals), so development of EFlow tools is hopefully consistent with that, i.e., EFlow approaches for basins and/or stream classes with higher withdrawal pressures should be developed first.

VII. October 18, 2011

- EFSAB will continue through 2012 and possibly beyond.

- Characterizing ecology and classifying streams is not an end in itself, but rather a means to an end. That end is a broad brush approach that can be applied to the diversity of streams across the entire state, with a minimum of site-specific data collection.

November 15, 2011

- EFlow calculations will be used to identify “red flags”, which means there may be a problem with ecological integrity in the 20- to 50-year planning horizon. The intent of the “red flow” is not to come up with an exact prescription for a problematic scenario.
- NC river basin models currently do not include EFlows, only flows associated with permitted dams and/or withdrawals.
- If EFlows are not included in river basin models, models assume any and all water, excepting permitted flow requirements, can be withdrawn to meet demands.
- EFlows would be used as a planning tool for river basin models and plans. They would be used to “flag” locations where off-stream demands and in-stream EFlow needs cannot be met under existing or projected conditions. When the model is run containing EFlows, if a “red flag” is raised then this would indicate that closer examination is needed to either confirm the EFlow need at that particular location and/or evaluate other options to meet off-stream demands.
- DWR can test a presumptive standard as an EFlow. The 7Q10 is the lowest extreme of the presumptive standard spectrum and not likely to maintain ecological integrity. **Revised to: DWR may test presumptive standard as an ecological flow. There is value in testing a literature based approach (replace presumptive standard with literature based approach) in Oasis to demonstrate where the red flags show up (Tar, Lumber). Other group also raised concerned about this section about whether 7Q10 is the lowest extreme (consider striking as may not be accurate).**

VIII. January 17, 2012

- Regarding the concern that DWR is developing models as scheduled without EFlows, modeling for almost all of the major river basins in North Carolina is expected to be completed by 2014. It’s true that DWR has a placeholder for EFlows. However, the timeline for local governments looking forward is 20 to 30 years. Generally, for now, DWR believes its water management and planning is not significantly impacting the ecology in the state. These models will assist cities, communities, and planning organizations, and DWR in looking 20 to 50 years into the future. DWR does not believe it is critical at this juncture to have EFlows in the model 18 to 36 months from now when looking out 20 to 30 or 50 years into the future.
- A separate stakeholder process may be established to advise the General Assembly and DWR on how to implement a new flow policy that is based on current scientific knowledge. The EFSAB and DWR are focusing on whether future projected off-stream uses of North Carolina’s rivers and streams are going to have a negative impact on aquatic ecology. A separate stakeholder group can assist the General Assembly to determine what action needs to be taken to respond to negative impacts, which is a policy decision and outside the scope of the EFSAB.

IX. February 21, 2012

- One product of each basin model is a river basin water resources plan. The model is a tool to help DWR make evaluations in time and space across a basin. EFlows are being used for planning. When DWR determines that there are places in future projections where an impact may occur on ecological integrity or water supply availability, the plan will lay out different alternatives for people to consider. That is what the EFSAB’s work is building towards.

X. April 24, 2012

- Since the EFlow approach(es) will be used in long-range planning, it is preferable to establish criteria that, if in error, are on the side of EFlows that are slightly too high – a “false positive red flag”. EFlow criteria that are too low (“false negatives”) are undesirable because, if an error is discovered later during a site specific study there would be much less lead time remaining for a water system to develop options to meet increasing water supply demands.

XI. June 19, 2012—none noted

XII. August 28, 2012

The group is aiming to plug in the EFlows for all the yellow dots (nodes) represented in the OASIS models.

XIII. October 23, 2012 --none noted

XIV. November 27, 2012

- The work and focus of the EFSAB is not policy but a review of scientific information to assist DWR with planning for future water supply use.
- For the purposes of DWR, the EFlow metrics will be placed into the basin hydrologic models to “flag” watershed streams where EFlows could be adversely impacted by projected withdrawals.
- Information of adverse impacts will be brought back to the Environmental Review Committee (ERC) of the General Assembly to determine what action to take.
- Any action that results from the work of the EFSAB will be action that the ERC takes (as the originator of the policy), not the EFSAB, whose responsibility is solely to provide the scientific information. The ERC is expected to take any information provided by DWR about EFlows and determine whether policy will be made or not.
Proposal to strike all 3 comments/ bullets in red.

Appendix B: Outline of Identified Issues Remaining for EFSAB to Address

Outline of Identified Issues Remaining for EFSAB to Address February 15, 2013

Two documents follow this preface. The 2 documents are:

- 1) a brief outline of the identified remaining issues to address; the facilitators envision using this outline to test for understanding and as a starting point (along with additions made by the EFSAB at the February meeting) for planning the next several meetings (pages 1-2);
- 2) a more detailed outline showing the addition of many questions/comments that have been raised under each category (pages 3-6).

In these documents, the comments listed in burgundy were provided to the facilitators by DWR on 2/14/13; the comments listed in black are comments/questions made by EFSAB members during meetings and compiled by the facilitation team.

THE OUTLINE

- I. **Continue Development of a shared definition of the charge**
 - A. **Comments from DWR on 2/14/13**
 1. **These ecological flows are being developed for planning purposes, not policy**
 2. **Clarify distinction**
- II. **WaterFALL**
 - A. **Question from DWR (2/14/13):** Will WaterFALL suffice for generating flows for EFlows analysis (PHABSIM and BEC)?
- III. **Characterizing the Ecology**
 1. **Comments from DWR (2/14/13):**
 - a. First choice would be successful completions of RTI's Biological-Environmental Classification (BEC)
 - b. If that doesn't work out, then at least 3 classes (definitely more, such as inner/outer (and/or tidal-non-tidal) coastal plain, sand hills, foothills)— mountain, piedmont, coastal – based on DWR's best judgment and drawing on the white paper from Jim and Fred.
 - c. 2nd preference would be geographic/physiographic/etc. GIS overlay similar to effort by TNC in NE US and currently underway in SE US.
- IV. **Approaches to recommending eflows**
 - A. **Notes from DWR on 2/14/13**
 1. **EFlow Approach for Each Stream Class**
 - a. **Mountain Class(es)**
 - i. **BEC may not work (not enough spread in biological and hydrologic alteration— Tom Cuffney's work may inform).**
 - ii. **This leaves PHABSIM or literature-based as options**
 - iii. **Staff resources to complete PHABSIM analyses within time frame will be a challenge**
 - b. **Piedmont Class(es)**
 - i. **BEC may work**
 - ii. **PHABSIM or literature-based also remain as options**
 - iii. **Resources to complete BEC and/or PHABSIM analyses within time frame will be a challenge**
 - c. **Coastal Class(es)**
 - i. **Define by downstream limit of OASIS models**
 - ii. **Subdivide into inner and outer coastal plain?**

- iii. Will require a different approach – not BEC or PHABSIM – possibly water quality and/or salinity based; or perhaps a flood or water elevation model such as HEC-GeORAS (USACOE). Coastal areas have been mapped by NC Floodplain Mapping Program.
 - iv. Need to narratively describe what will be done, but will not be able to actually complete analysis and EFlows algorithm for coastal streams within time frame.
2. Issues for All Stream Classes
- a. Will WaterFALL suffice for generating flows for EFlows analysis (PHABSIM and BEC)? If not, then literature-based approaches are the only option.
 - b. How will existing large reservoirs be handled? What will be the baseline for degree of hydrologic alteration (BEC) or unregulated hydrology for habitat time series analysis (PHABSIM)? Will rivers with existing large reservoirs be their own class? On streams with dams and/or permitted withdrawals, what is the downstream break line between upstream dams/water withdrawals with flow requirements and downstream reaches with EFlows?
 - c. In addition to the science analysis, the EFlows SAB will need to reach a consensus on what is good enough science and what is an allowable degree of flow/ecological alteration.

- V. Species/guilds
- VI. General
- VII. Literature needs
- VIII. Report Writing and Timing
- IX. Going forward from final report
- X. Add anything from “DWR Assumptions” discussion that does not have consensus at 2/19 meeting.

THE ANNOTATED OUTLINE

- I. Continue to Develop a shared definition of the charge
 - A. **Comments from DWR on 2/14/13**
 - 1. These ecological flows are being developed for planning purposes, not policy
 - 2. Clarify distinction
 - B. What does “comparable to prevailing ecological conditions” mean?
 - C. Define balance [as used in the legislation]
 - D. Who is the EFSAB’s audience?
 - E. Do the recommendations need to be scientifically defensible, which would require experimentation? Or do we come up with consensus principles, that what we do and offer can be explainable, but we may not be able to defend them.
- II. WaterFALL
 - A. **Question from DWR (2/14/13):** Will WaterFALL suffice for generating flows for EFlows analysis (PHABSIM and BEC)?
- III. Characterizing the Ecology
 - A. Do by classification?
 - 1. **Comments from DWR (2/14/13):**
 - a. First choice would be successful completions of RTI’s Biological-Environmental Classification (BEC)
 - b. If that doesn’t work out, then at least 3 classes (definitely more, such as inner/outer (and/or tidal-non-tidal) coastal plain, sand hills, foothills)– mountain, piedmont, coastal – based on DWR’s best judgment and drawing on the white paper from Jim and Fred.
 - c. 2nd preference would be geographic/physiographic/etc. GIS overlay similar to effort by TNC in NE US and currently underway in SE US.
 - 2. Wait for BEC?
 - 3. Other classification

- a. Mountains, piedmont and coastal plain?
 - a. How to address Coastal plain
 - i. OASIS models don't work below tide line
 - ii. Paucity of data in the coastal plain
 - iii. Need to account for effects occurring up- and down-stream
 - b. SALCC? (what is timeline for SALCC?)
 - c. what Henriksen is proposing nationally that is: explainable, understandable, and makes sense (that leads with criteria of flow variables and ties in physiographic variables). This system is fairly flexible in terms of the amount of aggregation that each state could use with regard to that classification.
- 4. Process of evaluating the classifications is not just about biofidelity, it's also about what else do we know about these groups, these classes that might affect the interpretation of eco-flows. This may include: soil types, land use types, the types of things we normally use to explain biological behavior. What information do we have? Where are the gaps? Where are the sources? What are the things that would be important for driving hydrology and the ecological responses?
- 5. How to tie in unregulated streams or smaller streams
- B.** How to address invertebrates in the HSCs?
- C.** Issues to address in characterizing ecological integrity
 - 1. Resilience
 - a. How much "disruption" can occur that still allows "recovery"?
 - b. How long does it take an ecosystem to recover when the flow drops below the e-flow?
 - c. We need a yardstick to measure resilience.
 - 2. Ecological integrity should account for complexity and for variability in many aspects: thermal, hydrologic, biologic, etc.
 - 3. What if flow is not the determinant factor supporting ecological integrity in a particular classification of stream? Should this be determined?
 - 4. Only address aquatic systems?
 - 5. It is important to know the changes in the graph, the point at which things change.
 - 6. Altered or unaltered.
 - b.** if it is altered, is it altered in terms of hydrology or altered in terms of pollution or other reasons.

IV. Approaches to recommending eflows

A. Notes from DWR on 2/14/13

1. flow Approach for Each Stream Class

a. Mountain Class(es)

- i. BEC may not work (not enough spread in biological and hydrologic alteration).**
- ii. This leaves PHABSIM or literature-based as options**
- iii. Staff resources to complete PHABSIM analyses within time frame will be a challenge**

b. Piedmont Class(es)

- i. BEC may work**
- ii. PHABSIM or literature-based also remain as options**
- iii. Resources to complete BEC and/or PHABSIM analyses within time frame will be a challenge**

c. Coastal Class(es)

- i. Define by downstream limit of OASIS models**
- ii. Subdivide into inner and outer coastal plain?**

- iii. Will require a different approach – not BEC or PHABSIM – possibly water quality and/or salinity based; or perhaps a flood or water elevation model such as HEC-GeORAS (USACOE). Coastal areas have been mapped by NC Floodplain Mapping Program.
 - iv. Need to narratively describe what will be done, but will not be able to actually complete analysis and EFlows algorithm for coastal streams within time frame.
 - 3. Issues for All Stream Classes
 - a. Will WaterFALL suffice for generating flows for EFlows analysis (PHABSIM and BEC)? If not, then literature-based approaches are the only option.
 - b. How will existing large reservoirs be handled? What will be the baseline for degree of hydrologic alteration (BEC) or unregulated hydrology for habitat time series analysis (PHABSIM)? Will rivers with existing large reservoirs be their own class? On streams with dams and/or permitted withdrawals, what is the downstream break line between upstream dams/water withdrawals with flow requirements and downstream reaches with EFlows?
 - c. In addition to the science analysis, the EFlows SAB will need to reach a consensus on what is good enough science and what is an allowable degree of flow/ecological alteration.
- B. OASIS/WaterFALL
 - i. Will WaterFALL suffice for generating flows for EFlows analysis (PHABSIM and BEC)?
 - C. Are we going to determine threshold holds or algorithms for eflows by class?
 - D. Is it better to err on the side of the bar being high so that a flag is thrown up in time to allow pursuit of alternative approaches?
 - E. Do eflows by class or basin by basin as hydrologic models become available?
 - i. Opportunity for process (reconvening EFSAB) to do basin by basin approach?
 - F. Are we going to approach this from an ecology/ecological integrity versus hydrology evaluation, or are we simply going to base it on available habitat and flow alteration?
 - i. Do we see these [habitat] models responding to proposed ecological flow recommendations, and does that help us figure out if something makes sense or not?
 - ii. DWR look at more IFIM studies and present results?
 - iii. Does the habitat modeling accurately predict the effect on habitat as flow is altered (validate the model)?
 - iv. Do changes in habitat translate into something that is biologically meaningful (does habitat predict biology)?
 - v. Is the EFSAB going to characterize the ecology in some way other than habitat?
 - vi. If do, keep >120%?
 - vii. Develop criteria for success for habitat modeling
 - viii. What percent change in habitat is acceptable?
 - G. Do we think that based on science: % inflow maintains a natural hydrograph with the duration and frequency and these pieces tend toward maintaining ecological integrity, whereas the 7Q10 and even mean annual or mean monthly flows, as demonstrated by Fred's illustrations, cuts that off?
 - H. How to address tidal waters?
 - I. How long does it take an ecosystem to recover when the flow drops below the e-flow
 - J. What is the line that if crossed, the system will not recover?
 - K. Investigate the differences in withdrawal and low flow types of impacts versus changes in biological assemblage due to shift in stream class as a result of urbanization.
 - L. When is the "red flag" raised? Any time EFlow is breached? Frequency? Duration? %Q? Seasonal?
 - M. How to address that alterations in the upper watershed are attenuated in the lower watershed by intervening drainage and discharges. Nodes in lower watershed may not raise a "red flag".
 - N. How to address tidal waters?
 - O. How to capture secondary and cumulative impacts
 - P. How to address land use

- Q. Address high-flow skimming? There's a lot of available water during high-flow events
- V. **Species/guilds**
 - A. Use Chris's proposed guilds?
 - B. Also use endangered species that are not part of a guild?
 - C. Is there a list of species that has requirements that are different from the guild list?
- VI. **General**
 - i. Most of our discussions have focused on minimum flows to maintain biology, but it is also important to consider high flows to maintain biology.
 - ii. How/if to address high flows
 - iii. How/if to address land use change.
- VII. **Literature needs**
 - A. NCDWR should distribute Hatfield & Bruce meta-analysis to EFSAB as a follow-up from Payne's presentation.
 - B. NC DWR: papers referenced in Coastal Waters presentation to be made available to EFSAB.
- VIII. **Report Writing and Timing**
- IX. **Going forward from final report**
 - A. How will monitoring be accomplished?
 - B. Make best attempt now and build into recommendations to reconvene the EFSAB at a later date? What criteria would trigger that?
- X. **Add anything from "DWR Assumptions" discussion that does not have consensus at 2/19 meeting**

Appendix C: Proposed Report Template (Developed By DWR)

With Revisions proposed by Facilitation Team and EFSAB members (Feb 19, 2013 meeting).

Completing sections I-IV, would come close to an interim report. Question was raised - who is the audience? Report can be written for a general audience with appendices specific to the ERC and DWR.

Title of Report

- I. Executive Summary (develop last)
- II. Table of Contents
- III. Introduction
 - A. Background
 - A.1. Legislative directive (distinguish between EMC and ERC)
 - A.1.a. Science Advisory Board
 - A.1.b. Characterization and Ecological (deleted environmental) flow
 - A.1.c. Modeling
 - B. Summary of SAB process
 - B.1. Charter
 - B.2. Schedule
 - B.3. Website
- IV. Supporting information review
 - A. Published articles
 - A.1. Characterization through classification
 - A.1.a. Regional and state efforts
 - A.2. Environmental flows
 - A.2.a. Potential flow recommendation procedures
 - A.2.a.i. Minimum flow or flat flow
 - A.2.a.ii. Variable flow statistic
 - A.2.a.iii. Percent of flow statistic
 - A.2.a.iv. Percent of inflow
 - A.2.b. Basin and state efforts
 - A.2.b.i. Basins: Savannah, Potomac, Susquehanna
 - A.2.b.ii. States: Florida, Texas, Connecticut
 - B. Presentations
 - B.1. Modeling
 - B.1.a. OASIS
 - B.1.b. WaterFall
 - B.2. Characterization through classification

- B.2.a. Hydrologic characteristics: Environmental Flow Specialist
 - B.2.b. Biological responses
 - B.2.c. Multi-characterization overlays
- B.3. Ecological (deleted environmental) flow
 - B.3.a. PHABSIM: NC field studies
 - B.3.b. Coastal/tidal waters outside scope of present models
 - B.3.c. Other state efforts: Michigan, etc. (other state efforts reviewed by DWR/ General Assembly that initiated development of the SAB because NC wanted something different and other state info reviewed after development of SAB that has advance thinking about E-Flows in NC)
- V. SAB accomplishments and discussion (is there value to labeling contributions by year (contributions in 2011, in 2012, in 2013, in a summary format and then specifically articulating contributions by subject area?)
 - A. Characterization
 - B. Environmental flows
 - C. Trial balloons
 - D. Alternatives presented and discussed
 - E. Outstanding issues
 - E.1. Recommendations for Outstanding Issues
- VI. Recommendations
 - A. Recommendations
 - B. Dissenting reports (revised to – Alternative Opinions/Views: dissenting or minority report suggests inferior or challenging the prevailing view).
- VII. Literature Cited (change to Annotated Literature Review)

Appendix A: Legislation

Appendix B: SAB members

Appendix C: SAB Charter

Appendix D: Assessment of SAB Process

Appendix E: Annotated Meeting Information

Appendix F: Schedule of River Basin Modeling (or somewhere)